POWER PLANT ENGINEERING

Established Over 31 Years

VOL. XXXI CHICAGO, FEBRUARY 1, 1927 No. 3

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Published on the 1st and 15th of each Month by the

Technical Publishing Co., 53 West Jackson Blvd., Chicago

New York Office, 150 Nassau Street

Subscription price $2.00 a year in the United States and possessions. Canada $2.75 a year. Other countries $3.50 a year. Single copies 15 cents.

Copyright 1927, by Technical Publishing Co.

Entered as second class matter May 1, 1908, at the Post Office at Chicago, Illinois, under the act of March 3, 1879.

Member, Associated Business Papers, Audit Bureau of Circulations

Circulation of this Issue, 23,300

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Records a la Rubaiyat

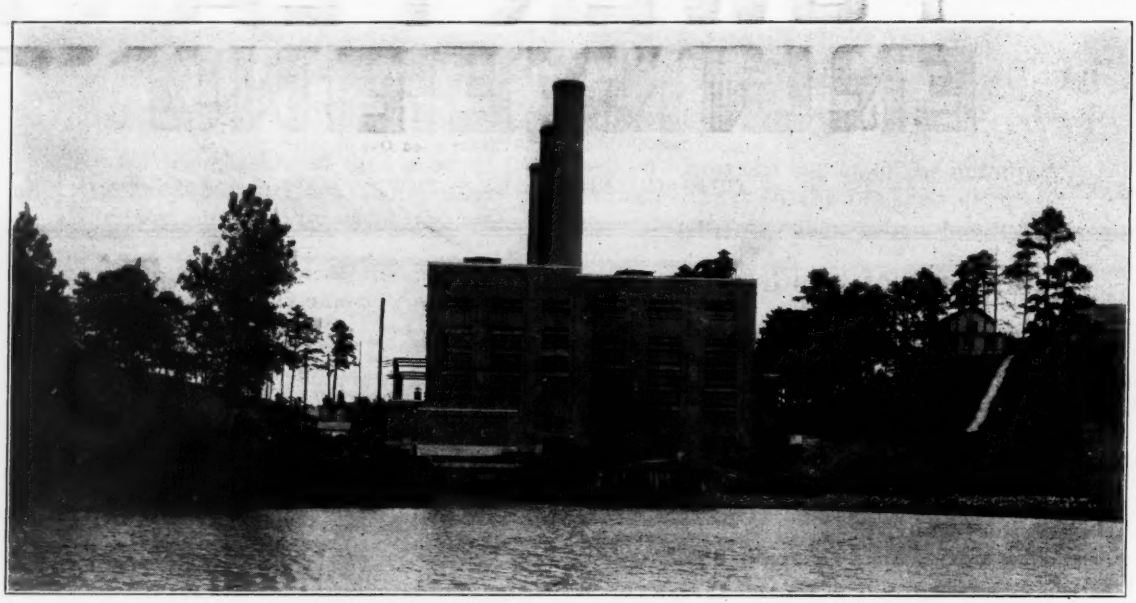
"WHEN OMAR smote 'is bloomin' lyre" (to paraphrase Rudyard Kipling) and produced the Rubaiyat, a philosophical poem, the famous old Persian tentmaker certainly must have just come from a visit to the power plant of the Naishapur Gas & Electric Co.

Otherwise, how could he have written these famous lines:

> "The Moving Finger writes and having writ
> Moves on; nor all your piety and wit
> Can lure it back to cancel half a line,
> Nor all your tears wash out a word of it."

Without question, this passage refers to the recorders in the great power plant at Naishapur, the moving pen arms of the instruments readily suggesting to any true poet the idea of the Moving Finger.

Well, the Moving Finger in every power plant writes some interesting things and none more interesting than in Columbia Power Station, the control room of which is shown above. No, that is not Omar Khayyam himself but one of his disciples, transcribing what the moving fingers of the recorders at Columbia have writ; namely, a new plant operating record of 12,495 B.t.u. per kw-hr. sendout. Full details of this important performance are given elsewhere in this issue.



Features of Parr Shoals Steam Power Plant

South Carolina Generating Station Designed for an Ultimate Capacity of 80,000 Kw. Burns Pulverized Coal. By R. D. Stauffer*

RAPID DEVELOPMENT and expansion of the cotton manufacturing industry on the South Atlantic seaboard has given rise to a large demand for power service in that territory. It was largely in response to this demand that the Parr Shoals plant was built.

Before construction was started, the territory was served by three hydraulic stations with two steam stand-by plants, whose output was entirely inadequate to meet the potential demand for power, even under the most favorable water conditions, and during low water periods it had sometimes been necessary to curtail service to important consumers. It was, therefore, necessary, after deciding to build, to rush construction with all possible speed, and the engineering organization handling the work is to be congratulated on the results obtained. Construction work was started on November 1, and by the latter part of the following August the plant had entered upon a period of operating under continuous overload lasting several months. The necessity for this rapid construction was accentuated by the fact that the season was the dryest known since 1845.

Parr Shoals Station is designed for an ultimate capacity of 80,000 kw. Its present rated capacity is 42,500 kw. consisting of two Westinghouse turbo-generators of 12,500 kw. and 30,000 kw. capacity respectively, utilizing steam at 315 lb. pressure and 675 deg. F., and generating 60-cycle, 3-phase current at 13,200 v. which is raised by "Y" connected transformers to a transmission line potential of 110,000 v.

Before construction work was started, a careful study was made of the situation in all its economic and physical aspects. The station was to serve as a stand-by for the water power plants and would sometimes have to run continuously for long periods, much of the time under heavy load. It had to be absolutely reliable. It had to deliver its output at low cost and had, therefore, to be highly efficient, but first cost and operating expense were to be kept as low as possible. It is a cardinal principle with the Barstow engineers not to install any equipment which will not pay its way, either in saving effected or in the more intangible field of improving general operating conditions.

In this case the study was unusually complete and resulted in decisions to use bent tube boilers, pulverized fuel, a combination of radiant and convection type superheaters, economizers of moderate size, furnaces with air-cooled walls, surface condensers and a filtering plant for boiler water. The economic study, as well as the previous experience of the organization, showed that a steam generating station could be built and operated at a cost almost as attractive as a hydro-electric plant

*Engineer, The W. S. Barstow Management Association, Inc.

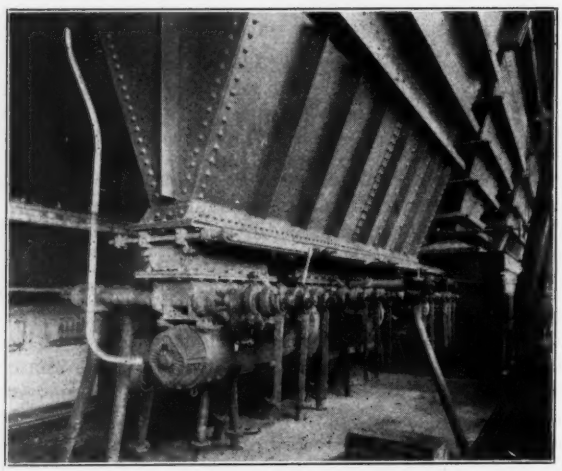


FIG. 1. PULVERIZED COAL FEEDERS

and, as a result, it was decided to make the Parr Shoals station one of the most efficient plants in the southern states. It is expected that, as the business in the territory grows, the steam plant will more and more become the company's chief source of power.

Electricity generated will be distributed in Columbia, Spartanburg and throughout an extensive territory in central South Carolina. The hydro stations, in conjunction with which the new steam plant operates, are located nearby—one at Parr Shoals, having a rated capacity of 15,000 kw., one at Gaston Shoals of 11,000 kw. rated capacity, one at Columbia of 5500 kw. rated capacity, one at Tuxedo and one at Turner Shoals of 5000 kw. rated capacity and one at Chimney Rock of 3500 kw. rated capacity.

The plants are linked together by high tension transmission lines, forming a system nearly 200 mi. in extent —reaching from Spartanburg and vicinity through Columbia and the Ridge section southwest to within a few miles of Augusta, Georgia.

Construction work was carried on in two parts. The first part included the main portion of the building and the first unit of 12,500 kw. capacity complete with boilers and auxiliaries. This machine was placed in operation at the earliest possible moment, long before the details of the station were complete. Then followed a period devoted to completing the work on equipment not absolutely necessary for carrying the load, checking up probable requirements, determining the equipment for the next section and making the layout and designs for its construction. The load increased so rapidly after

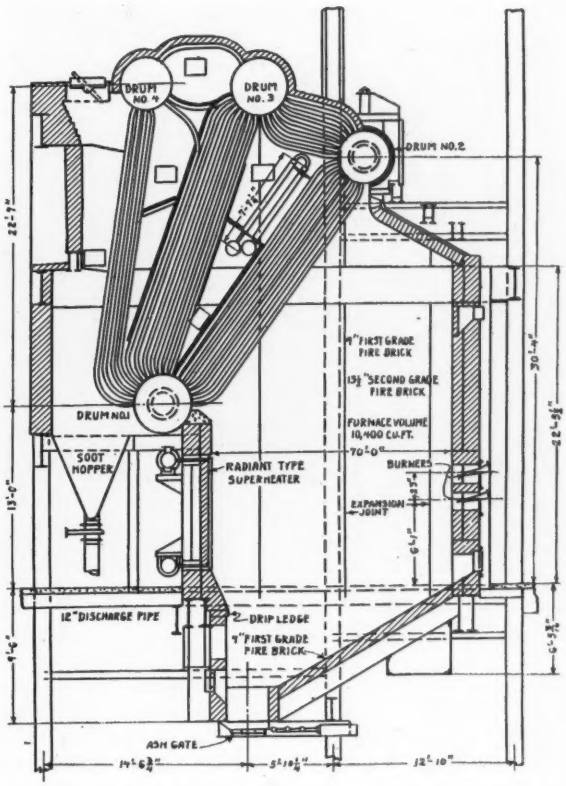


FIG. 2. SECTION THROUGH ONE OF THE BOILERS

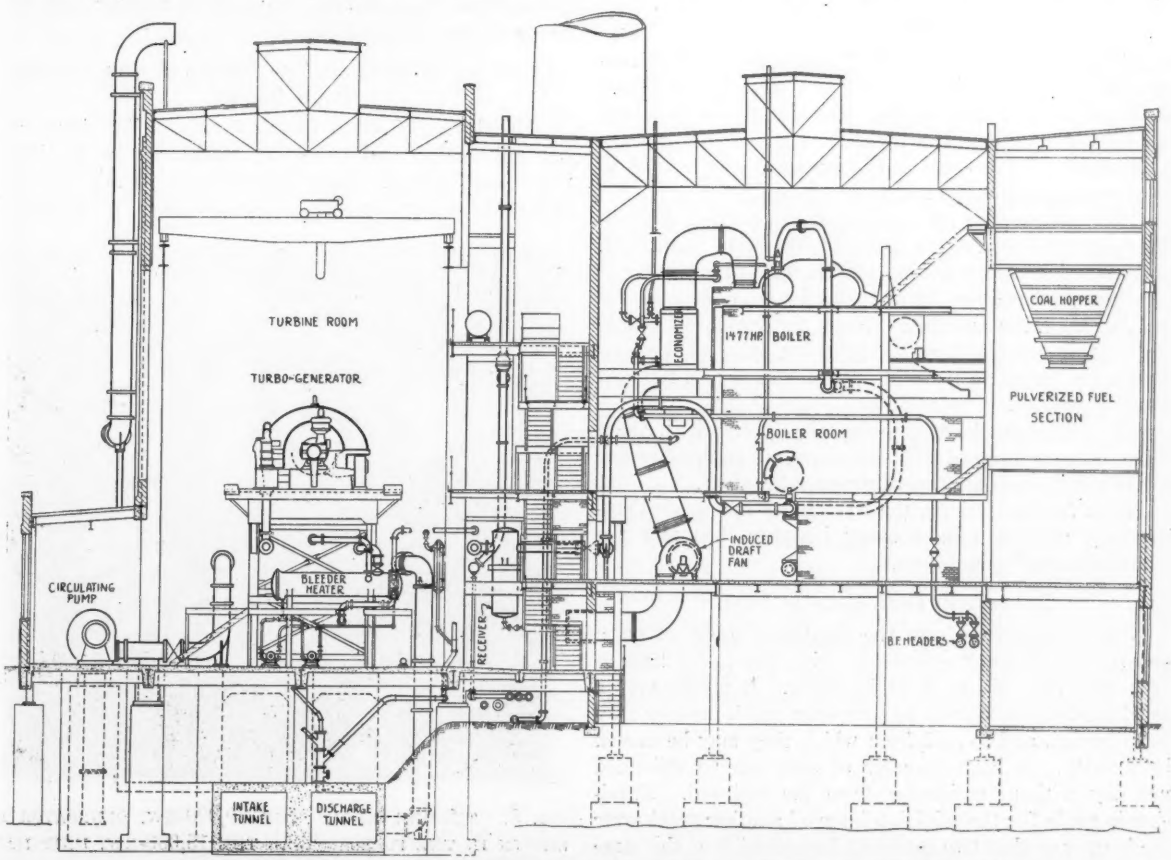


FIG. 3. THE GENERAL ARRANGEMENT OF THE PLANT IS SHOWN IN THIS DRAWING

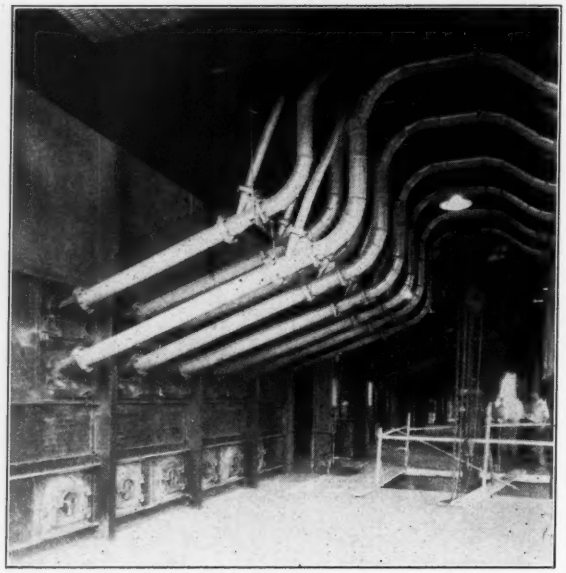


FIG. 4. BOILER FRONTS, SHOWING PRIMARY AIR AND FUEL PIPING

the size of the first unit was determined that it was found advisable to make the second unit of 30,000 kw. capacity or more than double the size of the first. This unit has recently been put in service, but much still remains to be done before the installation is complete and ready for its most economical operation.

Operation

The first unit of the station went into actual operation Sept. 1, 1925, and operated at a station load factor of 90 per cent the first month. Since that time the plant has been run at average monthly station load factors, ranging from 21 per cent in the month of April, 1926, to 82 per cent during the month of June, 1926.

The performance of the station has varied, depending upon the load factors, from 15,500 B.t.u. per kw-hr. to 19,200 B.t.u. per kw-hr. These are actual average monthly performance figures and include all coal for banking and for starting. These figures also include coal lost in pulverizing, transporting, etc., as the coal figures are based on the coal bought and not on the coal actually burned.

The plant can be very economically operated, there being only a total of 26 men required to operate the entire plant, each man working an 8-hr. shift.

With few exceptions, the equipment has proved satisfactory and, in almost every instance, has met the manufacturers' guarantees.

Pulverized Coal Used as Fuel

Coal is received from the Southern Railroad on a generous side track connected with the main line at both ends and laid on a slight grade. It passes over a reinforced concrete track hopper over which the cars may be unloaded, and to and from which they may be moved by gravity. A large number of cars can be unloaded per day without assistance from the railroad. Provision is made for the addition later of another track over the hopper so that two cars may be unloaded at the same time.

The track hopper is kept free from water by means of an electrically driven pump. Coal from the cars after passing through a grating is received by an apron feeder 30 ft. 30 in. center to center placed at right angles to the track and delivered by it to a belt conveyor. This conveyor consists of a sloping 5-ply belt, 30 in. wide and 264 ft. between end pulleys which elevates the coal, carries it over a weightometer where its weight is recorded and delivers it to the hopper of a Bradford breaker. From this hopper it may either be received by a conveyor, which drops it on the ground devoted to coal storage, or it may pass into the breaker. An extensive space is provided for storage. The coal is moved in storage by means of an electrically driven drag scraper and, when reclaimed, is dumped from this scraper into a reclaiming hopper from which it passes to the conveying machinery the same as described above.

Beneath the cylinder of the Bradford breaker is a hopper which receives the broken coal and delivers it to a belt conveyor which elevates the coal to a level slightly higher than the top of the bunkers. At its upper end is a magnetic pulley which removes tramp iron which might cause trouble in the mills, and over which the coal falls to a horizontal belt conveyor, extending the entire present and future length of the power house by which it is delivered to raw coal bunkers in the boiler room.

It has been found undesirable to store powdered coal for more than a day or two, as it is likely to absorb moisture and form troublesome cakes. There are also possibilities of fire so that a system of observing the temperature of the powdered coal bins at regular intervals has been found desirable.

Complete Pulverizing and Drying Equipment for Each Boiler

The drying plant is located in the boiler room and the pulverizing and transport machinery in the basement just beneath. There is one drier, one mill and one raw coal bunker for each boiler, and each boiler has its

FIG. 5. TURBINE ROOM. THE 30,000-KW. GENERATOR IS SHOWN IN THE FOREGROUND. THE 15,000-KW. UNIT MAY BE SEEN IN THE REAR

own pulverized fuel bunker. Coal may be delivered from any mill to any pulverized fuel bunker.

Coal passes from the raw coal bunkers through hand controlled gates to the driers beneath. These consist of chutes through which the coal slowly descends, broken by cross flues, one set of which receives heated air from a chamber at one side of the drier, passing it through the coal as it descends. The other receives the moisture laden air after it has filtered through the coal, and passes it to a chamber at the other side of the drier from which it is removed by a fan and discharged through a cyclone separator located on the roof. This separator removes a surprisingly large amount of coal.

Thermometers are provided to indicate the temperatures in the driers, and an alarm is installed to operate at any considerable excess temperature as a precaution against fire.

From the driers, the coal passes through a mechanical feeder, which controls the rate of flow to the mills where it is ground to a fine powder. These are motor-driven Fuller screen type mills. Within the grinding chamber four large chilled cast-iron balls are pushed along a grinding race-way by radially projecting revolving arms. Mounted on the vertical shaft which carries these arms are fan blades which create air currents, which remove the finely pulverized coal from the grinding zone and pass it through wire screens mounted near the outside wall of the mill. Pieces too large to pass the screens are returned to the mill, while the fine coal passes to a screw conveyor which carries it to the transport pumps. The air used to carry the coal from the grinding zone through the screens is discharged through a tall stack extending the entire height of the building and of considerable diameter. This gives a very small air velocity, so that no considerable amount of fuel is lost. The mills can be adapted to either anthracite or bituminous coal, but due to the location of the plant relative to the coal fields, probably only bituminous coal will be used. The fineness of the coal, as delivered by the mills, is such that about 85 per cent will pass through a 200-mesh sieve. It contains from 2 to 3 per cent moisture, which it does not pay to remove. It is entirely practicable to omit the drying process with most coals, but this results in a somewhat lower efficiency, increased power consumption, less capacity at the mills and somewhat less ease of operation. For these reasons it is planned to dry all coal fired.

The pulverized coal from the screw conveyor passes to the Fuller-Kinyon pumps for transport by compressed air through 6-in. pipes to the pulverized fuel bunkers above the boilers. These pumps consist of a cylindrical chamber, receiving the coal, in which a ring connected with an air compressor is centrally mounted. This ring receives air at about 40 lb. pressure and is fitted with jets discharging in the direction of the delivery pipe. The fuel is caught up by the air from these jets and transported at a high velocity through the pipes to the bunkers. These bunkers are tightly closed and fitted with stacks, extending through the roof, through which the transport air is discharged at low velocity so as again to avoid loss of fuel. Steam lines to the bunkers are provided so that in case of fire, steam may be used to prevent entrance of oyxgen and to assist in carrying away accumulated heat. Lights on a panel below indicate when each bunker is nearly full or nearly empty. When one bunker is full, the coal delivery is automatically diverted to the next in order.

The air compressor is fitted with an after-cooler to remove moisture which might cause the coal to cake and give trouble in the bunkers. It delivers the air at about 90 lb. pressure. The air for the pumping passes through a reducing valve. The higher pressure is piped to various points of the transport pipe system and used to remove quickly any obstruction, should it occur.

Pulverizing Equipment Electrically Interlocked

It will be noted that the coal handling equipment consists of a series of electrically driven machines, each receiving fuel from the one preceding it, and delivering it to the next in order. If any one of these machines should become disabled or stop, due to overload, a troublesome situation would result. To avoid this, the electrical control is so arranged that no machine can be started until the machine to which it delivers is in operation, and if any machine stops, all the machines through which its coal supply passes will stop—one after another, thus preventing piling up of coal at any point. When this occurs, an alarm is sounded to notify the attendant to remedy the difficulty.

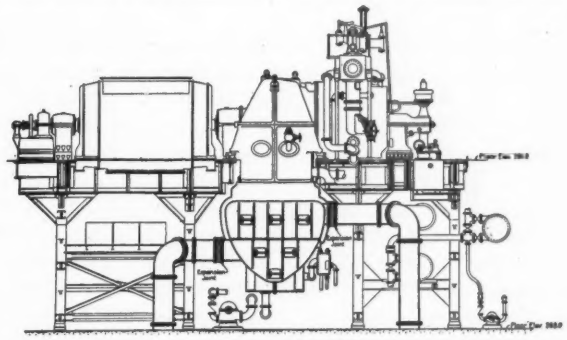


FIG. 6. ELEVATION OF THE 30,000-KW. TURBINE UNIT

Details of Boiler Equipment

Five Connelly boilers of the b nt tube type, each having a rated capacity of 1477 hp., are arranged in a row along one side of the boiler room. The mud drums are raised 13 ft. above the floor with blowoff pipes passing downward to the basement, and discharging into the condenser discharge water tunnel. Baffles are arranged for three passes. A convection superheater is placed between the first and second passes. In addition, there is a radiant type superheater located in the rear wall of the furnace. Steam passes in succession through the convection and radiant superheaters. This arrangement makes possible a very uniform amount of superheat over a wide range of load. Steam for the station auxiliaries is taken from a point between the two superheaters.

All boiler furnaces are built with hollow walls to provide air cooling of refractories, the heated air being used as secondary air for combustion. Special large fire brick shapes are used to permit expansion and contraction of the walls and suspended arch construction is used for parts of the furnace. Observation doors, provided with colored glass, permit inspection of the flame as well as every part of the walls. The bottom of the

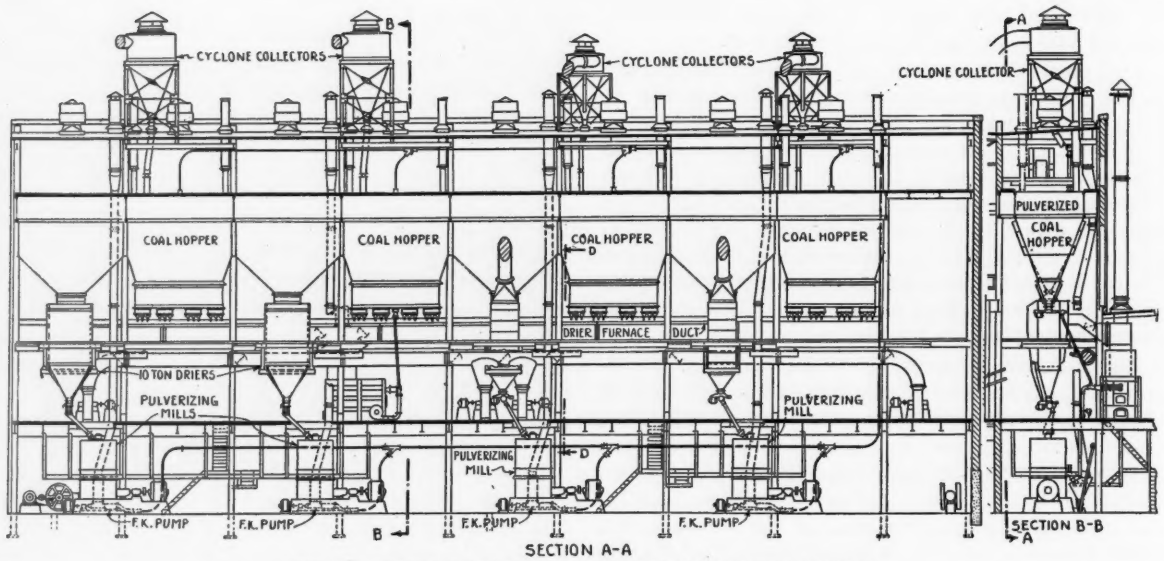


FIG. 7. DETAILS OF THE PULVERIZED COAL INSTALLATION

furnace consists of three air-cooled hoppers lined with fire brick, into which ashes fall and from which they are withdrawn through air-operated gates. Only about 15 per cent of the ash is thus accounted for. The remainder is discharged from the chimney as dust, so fine that no trace of it is ever found.

Each boiler has twelve burners. For each burner is provided a single screw feeder, mounted on the under side of the bunker. These are driven in groups of three by chain drive from direct-current variable speed motors. Alternating-current motors have not sufficient torque at low speeds for this purpose. Coal from the feeders passes through a short pipe to a special mixing tee, where it meets and is thoroughly mixed with air from the blast main at a pressure of about six inches of water, and passes to the furnace through a cast-iron burner as a flat rapidly moving horizontal jet. Burners are arranged in two rows, one above the other, across the face of the furnace. The air admitted with the coal is about one-third of the total required. The remainder is admitted around the burners, through the hollow walls and through openings in the lower rear part of the furnace.

Separate Economizers for Each Boiler

Each of the five boilers now installed is equipped with a separate economizer, located at the rear of the boiler. Those on the first two boilers each have 4416 sq. ft. of heating surface and those on the last three boilers each have 7600 sq. ft. of heating surface.

The gases pass downward to two induced draft fans, which discharge into a flue beneath leading to the stack. The fans are driven by adjustable speed alternating-current motors of the slip-ring type. Air-cooled dampers are provided. The boilers are normally operated at about 275 per cent of their rated capacity. The arrangement is such that the front row of tubes is exposed to the radiant heat from the furnace, thus considerably increasing its output and efficiency.

The stacks are of tapered reinforced concrete, lined to a height of 40 ft. They rest on massive concrete foundations, are 11 ft. internal diameter at the top and 150 ft. high. At the top is a metal cap with upwardly extending rods connected to a large copper cable with end carefully grounded for lightning protection. Each stack serves two boilers.

Two Generators Installed

Both turbo-generators were furnished by the Westinghouse Electric & Manufacturing Co. They receive steam at 315 lb. pressure and 675 deg. F. temperature, and deliver their output at 13,200 v., 60 cycle, 3 phase. The exciter circuit potential is 250 v. The unit first installed has a rated capacity f 12,500 kw. but it has been found capable of carrying 15,500 kw. continuously. It is designed for 28-in. vacuum and operates at 1800 r.p.m. The second unit is 30,000 kw. capacity.

Condensers are of the surface type, single pass, furnished by the Ingersoll-Rand Co. Leakage air is removed by 2-stage steam jet ejectors. The condensing plant departs somewhat from frequent practice in that a somewhat limited surface is provided, 9000 sq. ft. for the 12,500-kw. unit and 25,000 sq. ft. for the 30,000-kw. unit. Tubes are spaced and flow of steam arranged so that there is a minimum of idle surface. Separate from the main condensing chamber is a tubular cooler fed by a special connection from the circulating pump discharge, through which the steam and air mixture from the condenser passes on its way to the air ejector.

This permits a very large volume of air vapor mixture being withdrawn from the condensing chamber, resulting in a better utilization of its surface. The vapor is completely removed from this mixture by the cooler, due to the low temperature, the large special supply of cooling water and the generous surface provided. Thus the steam jets are required to remove less vapor and a higher vacuum is maintained. The efficiency is still further increased by using the rather high water velocity of 9 ft. per sec. in the condenser tubes. These tubes are ¾ in. outside diameter, No. 17 gage, of Admiralty metal. The condenser for the first unit is supplied with an external hot well which raises the temperature of the condensate nearly to the temperature corresponding to the vacuum, by means of steam taken from the top of the condenser, through which it is caused to fall.

Abundant Circulating Water Available

The circulating water is taken from the Broad River, which furnishes an abundant supply, as the plant is situated but a short distance above the dam of the hydro station.

Intake and discharge tunnels run beneath the basement floor. Circulating pumps are of 22,000 gal. per min. capacity and operate at 345 r.p.m. One is required to operate the smaller unit and two the larger one. Each unit has one pump equipped for dual drive, being direct connected to a steam turbine with reduction gear and to an induction motor. These turbines are the chief source of exhaust steam to control the heat balance. The load carried by the turbine and, therefore, the amount of its exhaust for feed-water heating, is regulated by a thermostatic controller located at the open heater from which the feed pumps take their water.

Each unit is arranged for complete independent operation with all its auxiliaries. Each condenser has one motor-driven and one turbine-driven hotwell pump. The pumps pass the condensate through closed tubular bleeder heaters, one for the smaller and two for the larger unit, from which it passes to combination jet and tray heater located on the floor above. The jet heater consists of several belts of inwardly directed nozzles, producing a spray through which the steam passes. Under conditions of moderate or heavy load it is extremely effective, raising the water temperature to within a degree or two of that of the steam. When, however, the supply of condensate is small, the nozzles no longer produce a spray and the trays in the tank beneath serve to heat the water. This tank is supplied with an overflow into a surge tank on the floor below. When the level in the heater tank is lowered, water from the surge tank is returned to the heater by means of pumps and a float valve, thus conserving water and heat.

This apparatus also serves effectively as deaerating equipment. The water in the heater tank is always within a degree or two of boiling and so readily gives up its oxygen, which is removed with a corresponding amount of vapor, by means of a Nash vacuum pump attached to the heater. This deaerating process is exceedingly vital in the operation of the plant, as the economizers are constructed of steel which is easily corroded by oxygen-bearing feed water. It also reduces the amount of pitting in the boilers.

All boiler feed pumps, with two steam-driven exceptions needed in starting, are motor driven. Under moderate load they are capable of delivering their output at a pressure of 425 lb. This pressure, in excess of the 325-lb. boiler pressure, is taken up by pipe and economizer friction and loss in the feed-water regulator.

Motor-driven pumps are also provided for house service, for furnishing gland water to the turbines, for pumping condensate from the bleeder heaters into the main condensate line and for removing the accumulated water from the drip tank. The pumps and condensers are located on the basement floor beneath the turbine room.

If any air should be permitted to leak into the exhaust steam system, it would throw an additional burden on the deaerating equipment and, if not there removed, it would cause corrosion of the economizers and feed-water lines. To avoid this difficulty the pressure is maintained slightly above the atmosphere by means of flow valves installed at the entrance to the jet heaters.

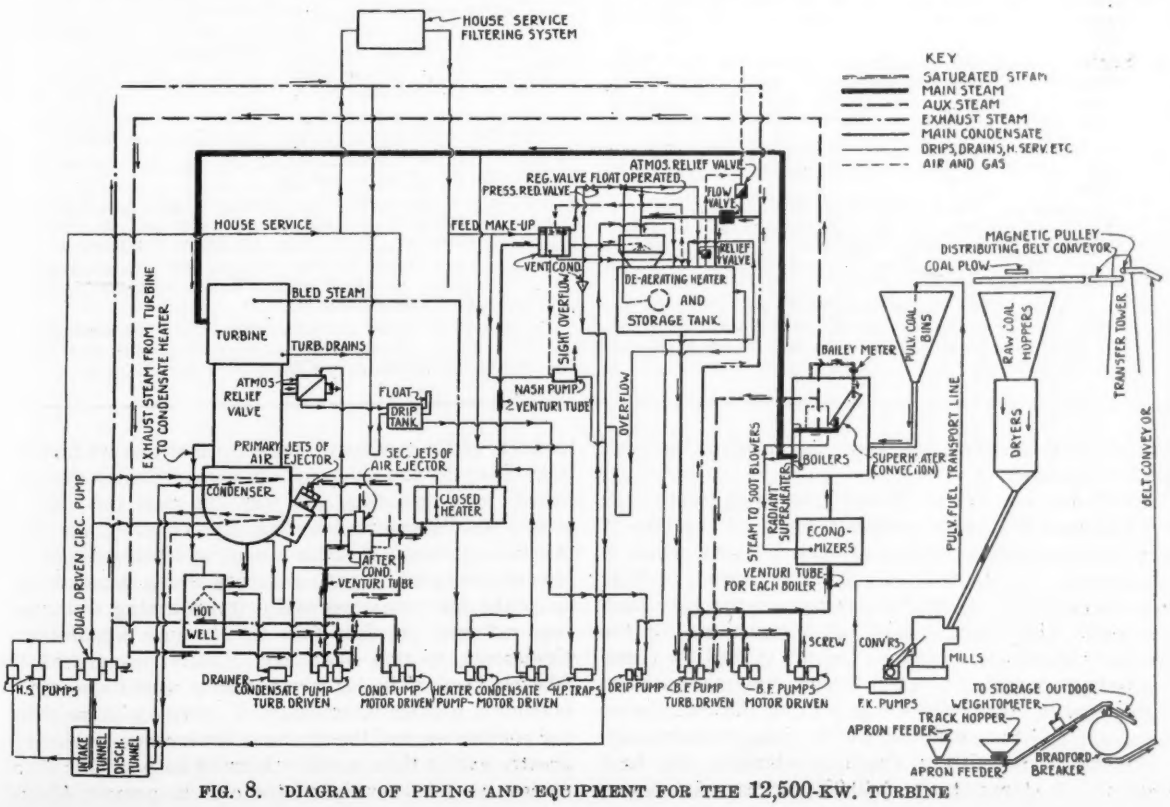


FIG. 8. DIAGRAM OF PIPING AND EQUIPMENT FOR THE 12,500-KW. TURBINE

Excessive exhaust pressure is avoided by means of a relief valve, which, due to the thermostatic control, almost never operates.

A complete line of meters and instruments has been provided to assist in economical operation of the station, including flow meters and thermometers for condensate and feed water, recording thermometers for economizer and flue gases and a complete layout of test wells and portable thermometers, so that any needed test can readily be made.

While the water of the Broad River is unusually soft and excellent for boiler purposes, much of the time it carries a considerable burden of very fine clay, which it was thought wise to remove. For this purpose a filter and sedimentation plant was erected on the high land adjacent. This plant consists of a storeroom for the necessary chemicals, a corner of which is used for chemical tests, a pumping plant, a large sedimentation basin with necessary tanks for slowly adding the coagulating chemicals, and two sand filters with piping and drainage arrangement permitting frequent cleaning by back washing. A storage tank of 40,000 gal. capacity is provided on the top of a nearby hill. The system also furnishes water for household purposes to a neighboring group of employes' houses, erected by the company.

Electrical Features

The electrical layout of the system presents many interesting features. In designing the station it was of fundamental importance to select the most advantageous frequency as this decision will vitally affect the industrial life of the territory served for many years to come. Both 40-cycle and 60-cycle equipment was in use, the former predominating. It was felt that the 60-cycle was by far the more desirable on account of the more satisfactory range of motor speeds which it permits, the somewhat superior lighting service which it makes possible, the somewhat less costly transforming equipment required and the fact that the 40-cycle apparatus is obsolescent, so that most new installations are of the 60-cycle type. The higher frequency would also render possible a greater interchange of energy with neighboring companies, and the giving of emergency service to a greater extent than would otherwise be possible. These reasons so far outweighed the cost to present 40-cycle

Principal Equipment at the Parr Shoals Steam Station

Turbo-Generators

1 12,500-kw. (15,625-kv.a.), 80 per cent power factor—13,200-v., 3-phase, 60-cycle, 1800-r.p.m., 4-pole turbo-generator.

1 75-kw. exciter, 250 v., directly connected to main unit, shunt wound.

1 30,000-kw. (37,500-kv.a.), 80 per cent power factor—13,200-v., 3-phase, 60-cycle, 1800-r.p.m., 4-pole.

1 135-kw. exciter, 250 v., directly connected to main unit, shunt wound, Westinghouse Electric & Mfg. Co.

Steam Boilers

5 Connelly water-tube boilers, 1477 hp., 325 lb. pressure. Each boiler has 1086 tubes 3¼-in. diameter, steam drum 42-in. diameter, water drum 48-in. diameter. Setting 28 ft. wide, 25 ft. 11½ in. deep, set singly.

5 Combination convection and radiant-type Foster superheaters, total temperature of steam 680 deg. F.

5 Foster economizers, two having 4416 sq. ft. and three having 7776 sq. ft. of surface. Power Specialty Co.

10 Induced draft fans, two fans per boiler, each driven by a 175-hp. Allis-Chalmers motor. B. F. Sturtevant Co.

Condenser and Pumps

1 Surface condenser, divided sections, 9000 sq. ft. tube surface, 2300 Admiralty metal tubes 20 ft. long. 1—primary air jet and 1—secondary air jet, inter and after condenser.

1 Surface condenser, single-pass, 25,000 sq. ft. Tube surface, 58,000 Admiralty metal tubes, 22 ft. ¾ in. long. 4—primary air jets (2 spares), 6—secondary air jets (2 spares), inter and after condenser.

1 Circulating pump, Cameron, 22,000 gal. capacity per min., 345 r.p.m., Motor and Steam turbine dual drive. Ingersoll-Rand Co.
1—Induction motor, 150 hp., Allis-Chalmers Co.
1—Steam turbine, 140 hp., single-stage, 315 lb. steam pressure, 2 lb. exhaust pressure. Drives circulating pump, 2450 r.p.m. Westinghouse Electric & Manufacturing Co.

1 Circulating pump, Cameron, 22,500 gal. capacity per min., 345-r.p.m. motor and steam turbine dual drive. 1—Induction motor, 225-hp., 3-phase, 60-cycle, 2300-v. Allis-Chalmers Co.
1—Steam turbine, 185 hp., single-stage, 300 lb. steam pressure, 2 lb. exhaust pressure. Drives circulating pump. Westinghouse Electric & Manufacturing Co.

1 Circulating pump, Cameron, 22,500 gal. capacity per min., 345-r.p.m. motor drive. Ingersoll-Rand Co.
1—Induction motor, 225-hp., 3-phase, 60-cycle, 2300-v. Allis-Chalmers Co.

2 Hotwell pumps, single-stage, motor-driven, 1750-r.p.m. Ingersoll-Rand Co.
2—Induction motors, 30 hp. each, 1750 r.p.m. Allis-Chalmers Co.

2 Hotwell pumps, 2-stage, one motor-driven, one turbine-driven, 1150 r.p.m. Ingersoll-Rand Co.
1—Steam turbine, 45-hp., single-stage, 1150-r.p.m., 315 lb. steam pressure, 2 lb. exhaust pressure. Westinghouse Electric & Manufacturing Co.
1—Induction motor, 50-hp., 3-phase, 60-cycle, 2300-v., 1750-r.p.m. Allis-Chalmers Co.

Heaters and Feed Pumps

3 Boiler feed pumps, 6-stage centrifugal. Capacity, 225 gal. per min. against a total head of 878 ft. Pennsylvania Pump & Compressor Co. One turbine-driven by Westinghouse 100-hp., single-stage turbine, 750 r.p.m. Two motor-driven by Allis-Chalmers 125-hp. induction motor.

2 Boiler feed pumps, 5-stage centrifugal. Capacity, 600 g.p.m. against a total head of 878 ft. Pennsylvania Pump and Compressor Co. One dual-driven by a Westinghouse 220-hp., direct-connected turbine and an Allis-Chalmers 250-hp. induction motor. One motor-driven by 250-hp. Allis-Chalmers motor.

1 Closed heater, 4-pass design, 1170 sq. ft. Capacity, 165,000 lb. of water per hr. Cochrane Corporation.

1 Closed heater, 4-pass design, 1690 sq. ft. Capacity, 230,000 lb. of water per hr. Cochrane Corporation.

1 Closed heater, 4-pass design, 1360 sq. ft. Capacity, 230,000 lb. of water per hr.

2 Cylindrical deaerating-type heaters with jet heater head. Capacity, 400,000 lb. of water per hr. 6-ft. inside diameter, 15 ft. long. Cochrane Corporation.

2 Single-stage House Service pumps, 500 gal. capacity, 1750 r.p.m. Morris Machine Works. Driven by 30-hp. Allis-Chalmers motors.

1 Single-stage House Service pump, 1300 gal. capacity, 1750 r.p.m. Pennsylvania Pump & Compressor Co. Driven by 75-hp. Allis-Chalmers motor.

customers of gradually replacing their motors with 60-cycle ones and the somewhat less ease of voltage regulation, that the higher frequency was determined upon.

As this change of frequency will be gradual and, as the old generating stations at Parr and Columbia will continue to furnish 40-cycle energy, it was determined also to erect a frequency changer station at Columbia, 30 mi. distant, to connect the 40 and 60-cycle systems together until the change, which will extend over a period of years, is fully accomplished.

The frequency changer station is connected on the 40-cycle side to the old steam generating station, and to the water power station at Columbia, and by two 66,000-v. transmission circuits to the water power station at Parr Shoals. One of these circuits has been insulated for 114,000 v. and can be used in emergencies to carry 60-cycle energy. On the 60-cycle side, the frequency changer station is connected with the incoming 114,000-v. transmission line from the new steam station.

Since it started, the frequency changer station has been running under heavy load and for a long time it was feared that the increased use of 40-cycle motors already installed, which accompanied the rapid general increase of business, might cause troublesome overload conditions. However, a considerable amount of change from 40-cycle to 60-cycle motors has been accomplished and the difficulty successfully passed.

The 60-cycle, 110,000-v. transmission line between the new steam plant and the frequency changer station at Columbia is broken at Lyle, situated a short distance outside of Columbia, by a 10,000-kw. bank of 114,000/13,200-v. transformers, so that the high tension voltage is not brought into the city.

From the 13,200-v. side of these transformers, a transmission line delivers energy to the towns of Lexington, Batesburg, Saluda and Johnson. A 60-cycle, 114,000-v. transmission line extends from Parr Shoals, some 70 mi. to a substation at the outskirts of Spartanburg, where it is stepped down by a 10,000-kw. bank of transformers to 33,000 v. The low voltage side of these transformers is connected by transmission lines with a hydro-electric plant at Gaston Shoals. It is planned to shut down the steam plant at Columbia, but for the present to hold it in reserve for emergency.

Principal Equipment at the Parr Shoals Steam Station—Continued

3 Twin strainers, used on discharge of service pumps. Andale Engineering Company.

Coal-Handling Apparatus

1 Grating for track coal hopper. Irving Iron Works.

1 Pan apron feeder, coal from track hopper to belt conveyor. Jeffrey Manufacturing Co.

1 Merrick weightometer, 100 t. capacity per hr. Merrick Sales Co.

1 Belt conveyor, 264 ft. c. to c. 5-ply. B. F. Goodrich Co.

1 Bradford coal breaker, 100 t. capacity per hr. Pennsylvania Crusher Co.

1 Belt conveyor, coal from breaker to transfer tower; 100 t. capacity per hr. Length 465 ft., 5-ply. B. F. Goodrich Co.

1 Dings magnetic separator, removes tramp iron from coal. Dings Magnetic Separator Co.

1 Belt conveyor, 569 ft., c. to c. Coal from magnetic separator to storage coal bunkers in plant. B. F. Goodrich Co.
Raw coal-handling system designed and erected by the W. G. Hudson Co.
250-t. structural steel. Carolina Steel & Iron Co.

1 Worm gear reduction on Bradford breaker. Foote Brothers.
200 return idlers, 290 troughing idlers for conveyor belts. Link-Belt Co.

Pulverized Coal System

4 Fuller coal feeders. 4—Coal dryers. 4—Vertical grinding mills. 3—Fuller-Kinyon coal transport pumps. 60—Burners. Transport lines. Fuller-Lehigh Co.

2 125-hp. and 3—150-hp. induction motors. Drive pulverizer mills. Allis-Chalmers Co.

3 Induction motors, 20-hp., 860-r.p.m., 3-phase, 60-cycle. Drive screw coal pumps. Allis-Chalmers Co.

4 Exhaust fans, steel plate, full housing, water-cooled bearings. Capacity each 10,000 cu. ft. per min. at 300 deg. F. against a static pressure of 6 in. Motor-driven.

4 Pressure fans, double inlet, capacity 11,000 cu. ft. per min. against 6-in. static pressure, at 865 r.p.m. Used with pulverized coal system. B. F. Sturtevant Co.

4 Induction motors, 20-hp., 440-v., 3-phase, 60-cycle, 865 r.p.m. Drive exhaust fans. 4—30-hp. induction motors, 440-v., 3-phase, 60-cycle, 865-r.p.m. Drive pressure air fans. Allis-Chalmers Co.

Miscellaneous Apparatus and Equipment

3 Chimneys, concrete, each 150 ft. high above the foundation. 11-ft. inside diameter at the top. Radial brick lined for 40 ft. from bottom. Two openings. Designed to withstand 100 mi. per hr. wind pressure and 800 deg. F. flue gas temperature. Rust Engineering Co.

6 Simplex water meters. Rate indicated in thousand pounds per hour. Two for condensate line between bleeder heater and jet heater; two for condensate out of condenser and two for total boiler feed water. Simplex Valve & Meter Co.

2 Air compressors house service. Motor-driven. Stroke 10-in. cylinder, 12-in. diameter, 276 r.p.m. Driven by 60-hp. motors. Pennsylvania Pump & Compressor Co.

2 Induction motor, 60-hp., 3-phase, 60-cycle, 440-v., 1555-r.p.m. Drive air compressor.

2 Motor sets, twin motors per unit, each 47-hp. capacity; total 97-hp. 1—30-kw. d.c. generator, 250-v., 1155-r.p.m. Allis-Chalmers Co.

1 Traveling crane, 75-t. capacity, 10-t. auxiliary hoist. Four motors span 35 ft., lift 53 ft., 3-phase, 60-cycle, 440-v. Niles-Bement-Pond Co.

5 Soot-blowing systems, each of 10 calorized units and four extra heavy steel units. One-half of these units on each side of each boiler. Diamond Power Specialty Co.

2 Boiler room meter boards, each containing two Bailey boiler meters. Two pens, one for steam flow, one for air flow. 2—Bailey multi-pointer draft gages, each with five indicators, one for primary air pressure, one for furnace pressure, one for pressure at economizer inlet draft, one for pressure at economizer outlet and one for pressure at induced draft fan. All indicate inches of water. 2—Bailey 4-pen recorders. Bailey Meter Co.

2 Cochrane vent condensers, cast iron, 202 sq. ft. heating surface.

2 Cochrane 10-in. multiport exhaust steam flow valve, Harrington type, hand-wheel control.

2 Cochrane 10-in. multiport back-pressure valve, vertical type, hand-wheel control.

2 Multiport back-pressure valve, 4-in.

Current from the generators passes over tubular copper leads insulated for 80,000 v. and mounted on 20,000-v. pillar insulators to a Westinghouse 25,000-v. oil circuit breaker, and thence to the 13,200-v. bus of the outdoor substation near the power house. The supporting structures of this substation are of structural steel.

A 132,000-v. Railway Industrial Engineering Co.'s pole top air break switch cuts off the station from all outside connections. Another group of similar switches, electrically interlocked, permits—in case of emergency—the use of one of the 40-cycle lines, reinsulated for the purpose, to carry 60-cycle energy to Lyle and Columbia. It is thought that this added flexibility will be a great

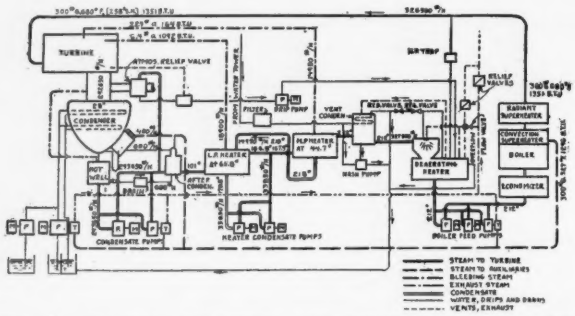


FIG. 9. DIAGRAM OF PIPING AND EQUIPMENT FOR LARGE TURBINE

help in maintaining continuous service. There is provided a full equipment of current and potential transformers for indicating load, and for control of apparatus.

All house transformers are oil insulated, self-cooled. A bank of three 50-kw., 13,200/220—110-v. transformers furnishes current for lighting and a few small power units. The auxiliary power for the smaller unit first installed is furnished at 440 v. by an Allis-Chalmers 2500-kw. bank of transformers; that for the second unit is furnished at 2300 v. by a 3750-kw. bank of Westinghouse transformers. There is also a 1500-kw. bank of Westinghouse 2300/440-v. transformers to tie the two systems together.

For emergency use, two additional banks of transformers are provided, one for power and one for light. Both take energy from the 2300-v. bus of the neighboring 40-cycle water power plant, thus insuring an entirely separate source of power. This connection is also made necessary to enable the steam plant to start if shut down, as coal must be ground and fans, pumps and coal feeders put in motion before the fires can be kindled and steam supplied by the boilers. The power transformer bank consists of three 50-kv.a., 2300/150—300—440-v. transformers. The 150-v. tap feeds the motor control circuits, the 440-v. tap feeds the 60-cycle, 440-v. motors and the 330-v. tap serves some 440-v., 40-cycle motors in the plant. Three 25-kv.a., 2300/230—115 v. transformers constitute the emergency lighting bank.

Step-up transformers for the transmission lines are oil insulated water cooled. For the smaller unit, three 15,000-kv.a., 13,200-v. delta connected 110,000-v. Y-connected transformers are provided. For the larger unit there is a similar bank of 37,500-kv.a. rated capacity.

The auxiliary power switchboard, furnished by the Westinghouse Co., is centrally located in a balcony on the side of the turbine room next the boilers. It is of the magnetic contactor type. To reduce motor trouble to a minimum, most of the motors are of the squirrel cage type, arranged to be thrown directly across the line in starting. When this is done, the ordinary switchboard overload protective devices are unsatisfactory, due to the fact that since they must pass the very large starting current of the motor, they cannot readily be made to open under smaller overload current, which if long continued, would destroy the motor. To obviate this difficulty, thermal relays, operating by means of heat continuously stored up during overload periods, are employed. This completely solves the difficulty. All coils are designed to operate with either 60 or 40-cycle current, 60-cycle being normally employed.

Lighting is controlled from a switchboard in the turbine room basement, and arranged to operate on either frequency. Turbine auxiliaries are all controlled by specially designed switches located near each motor.

Control System in Boiler Room

In the boiler room is a centrally located bench board for each two boilers, controlling for each boiler one

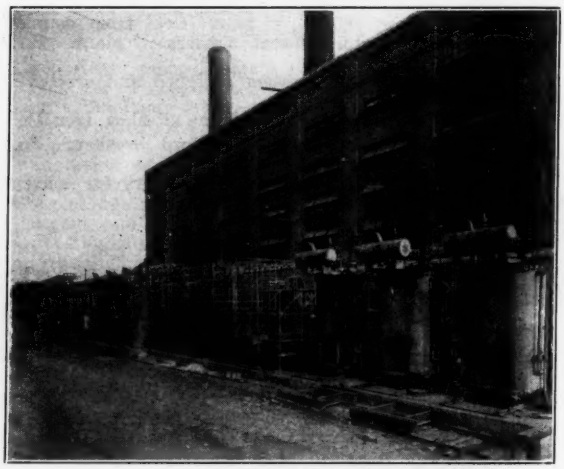
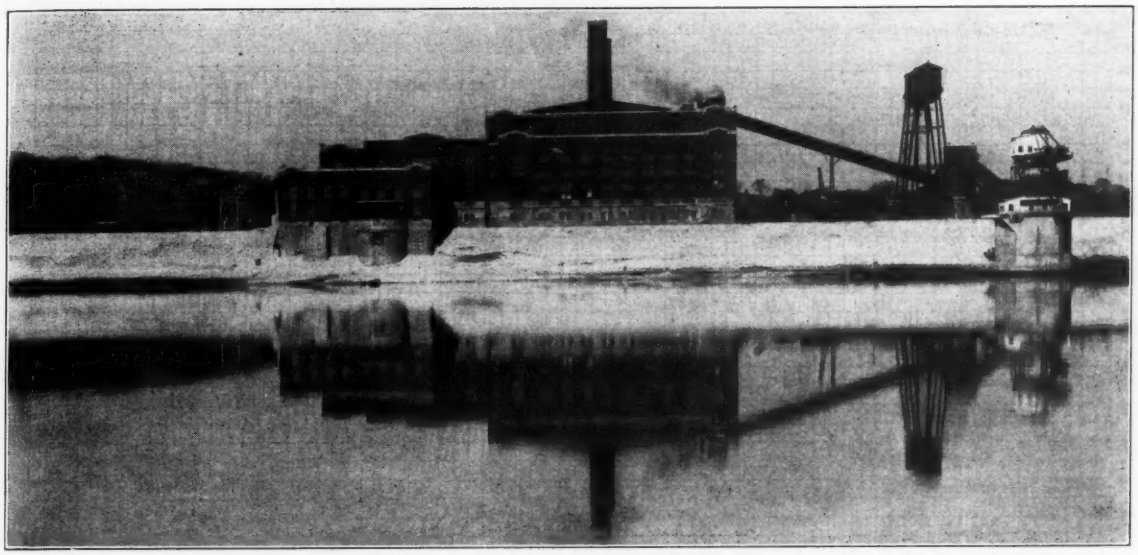


FIG. 10. HIGH-TENSION, OUTDOOR SUBSTATION, SHOWING TRANSFORMERS AND BUS STRUCTURE

30-hp., 60-cycle motor for primary air fan, two 175-hp., 60-cycle adjustable speed motors for induced draft fans equipped for five speeds, four 3-hp., 220-v., direct-current adjustable speed motors which drive screw feeders delivering powdered coal to the furnaces. As the rate at which the coal is fed is of vital importance, a specially designed interlocking rheostat is employed, arranged to give fine graduations of speed to any or all the motors. The necessary mechanical instruments for boiler control are mounted near the bench board. A pneumatic relay is connected to the blast pipe so arranged as to stop the feeder motors in case the air supply fails. If it were not for this, the excess coal, which would otherwise collect in the feeder pipe, would be likely to cause an explosion when the fire again is started. The control board for the raw coal handling equipment is located in a separate building near the track hopper about 500 ft. from the power house.



Columbia Sets Record of 12,495 B.t.u. per kw-hr.

With Average Plant Thermal Efficiency of 27 Per Cent for Oct., Nov., and Dec., 1926, Economies Are 12,657 B.t.u., 12,529 B.t.u. and 12,495 B.t.u. Per Kw-Hr., Respectively. By C. W. DeForest*

COLUMBIA POWER STATION of the Columbia Power Co., located on the Ohio River 20 mi. below Cincinnati, was put into operation about January 1, 1926 and has completed the first year of service. The power station was fully described in the February 1, 1926 issue of Power Plant Engineering. Briefly stated, the major features of the station's design and equipment may be summarized as follows:

Turbine equipment consists of two General Electric tandem units of 45,000 kw. each. The high-pressure unit of 14 stages is mounted on a single shaft with the low-pressure unit of 12 stages. Steam pressure at the throttle was initially 550 lb. at a total temperature of 725 deg., but has been raised to 600 lb. at a total temperature of 730 deg. The steam at a pressure of 110 lb. is reheated between the high and low-pressure cylinders to a temperature of 725 deg. Steam is extracted from three stages, the 24th, 22nd, and 18th, for feed water heating.

There are four Babcock and Wilcox boilers per turbine unit, consisting of three standard boilers and one reheat boiler. Each standard boiler unit consists of 15,110 sq. ft. of heating surface, 3184 sq. ft. of super-

*Vice-President, Columbia Power Co.

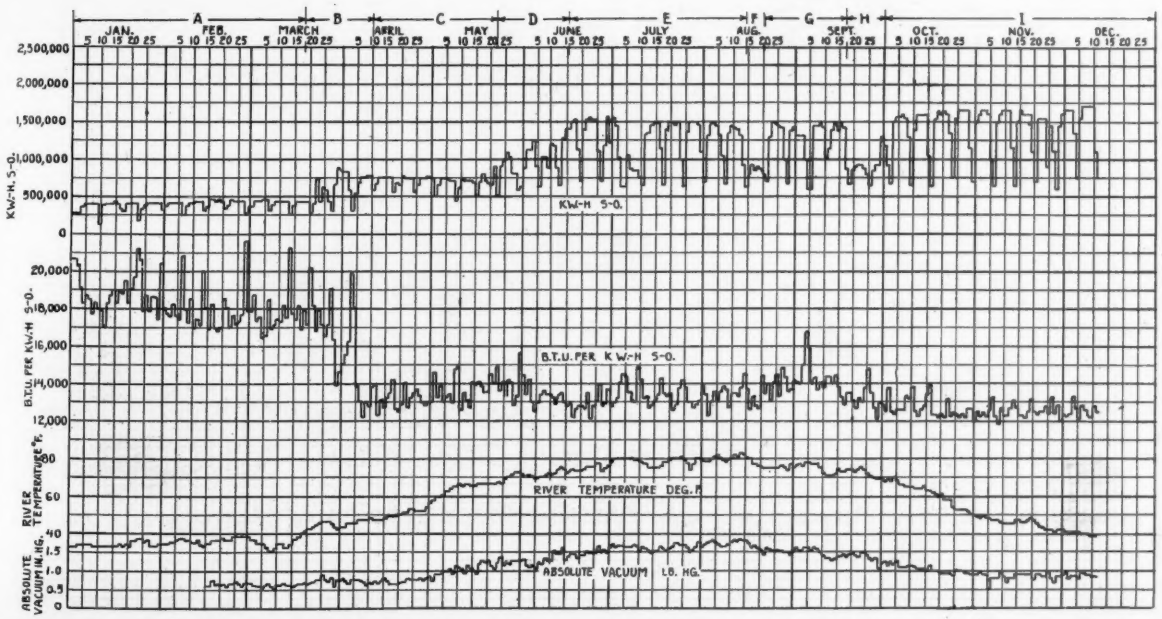


CHART 1. CURVES PLOTTED FOR 1926 SHOWING B.T.U. PER KW-HR. SENDOUT, TOTAL KW-HR., RIVER TEMPERATURE AND VACUUM

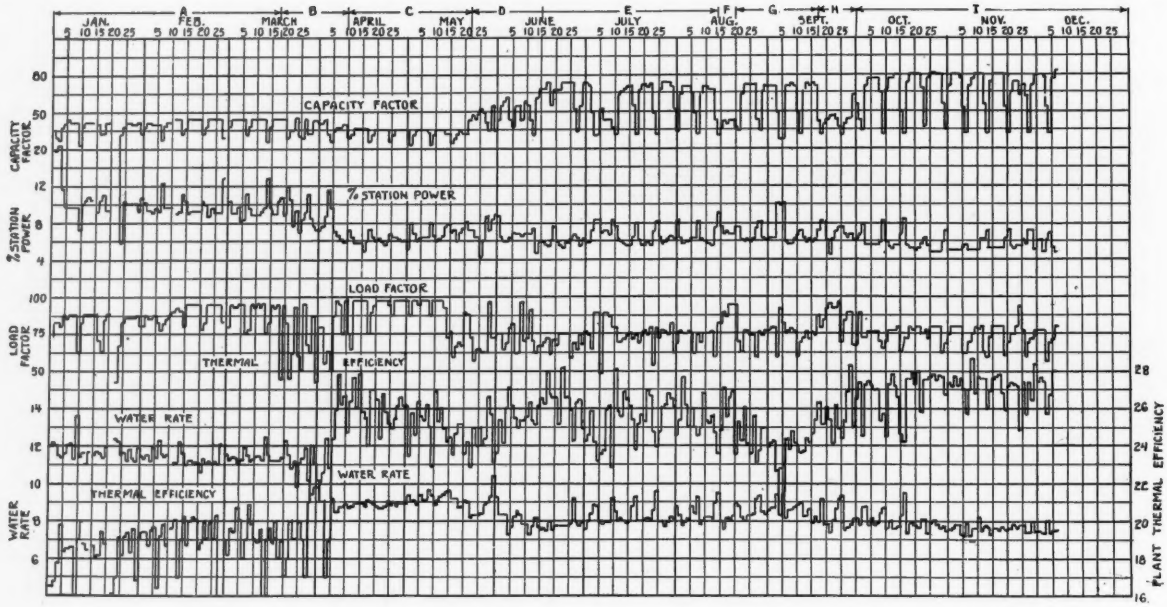


CHART 2. DATA FOR 1926 SHOWING WATER RATE, THERMAL EFFICIENCY AND LOAD CONDITIONS

heater surface, 7300 sq. ft. of economizer surface and 9885 sq. ft. of air preheater surface. Each reheat boiler consists of 6066 sq. ft. of heating surface, 1410 sq. ft. of superheater surface, 17,612 sq. ft. of reheat surface, 7300 sq. ft. of economizer surface, and 9888 sq. ft. of air preheater surface.

Furnaces are of the air-cooled refractory type, having a combustion space of 12,568 cu. ft. above the ash pits. The station uses pulverized fuel, all coal preparation equipment and burners having been furnished by the Fuller-Lehigh Co. The coal preparation equipment consists of six 57-in. and one 70-in. screen-type Fuller mills, two indirect pulverized-coal-fired rotary driers, and Fuller burners. Each furnace has nine vertical and six horizontal burners. Coal is received by barge and unloaded by a Mead Morrison river unloading tower equipped with a 4-t. grab bucket having a capacity of 375 t. an hour.

Current is generated at 13,200 v., and stepped up to 66,000 v. for transmission to Cincinnati and Dayton and a substation and transmission lines are under construction to transmit to Indianapolis at 132,000 v.

The kw-hr. sendout is the net kw-hr. supplied to the transmission lines, exclusive of all power and light used in the station, for coal unloading, storage and coal preparation. The accompanying tables of curves and other data give complete details of the operations beginning January 1, 1926. The curve plats are divided

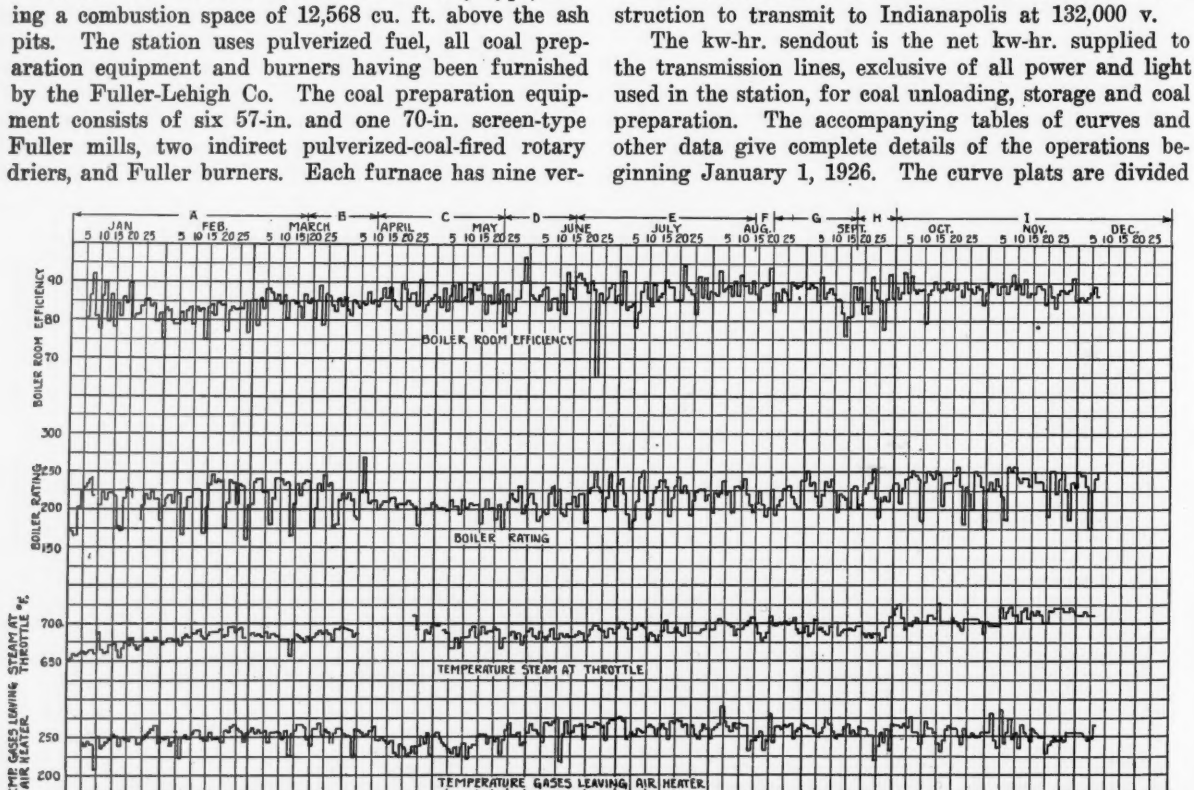


CHART 3. BOILER RATING, BOILER ROOM EFFICIENCY AND TEMPERATURES PLOTTED FOR 1926

into periods to show the various stages of the so-called "tuning up," and the improvements in operation as the difficulties were corrected.

Conditions of Operation

Conditions of operation during each period were as follows:

Period A. This represents operation on one unit with the high-pressure cylinder cut-out. Steam was supplied to the low-pressure cylinder at about 500 lb. pressure and 650 deg. total temperature. The pressure was throttled by the governing valve of the turbine.

Period B. Number 1 turbine unit operated on low-pressure cylinder, and No. 2 turbine unit started, using both high and low-pressure cylinders but without reheat

Period C. Number 1 unit shut down for work on high-pressure cylinder leaving No. 2 unit operating, as in Period B. The load was increased and the steam pressure raised to 550 lb.

Period D. Number 1 turbine was put into operation, using both high and low-pressure cylinders. Reheat cut in on both units.

Period E. Various station equipment was being tested. Changes in and improvements to furnaces and boilers were being made. The initial temperature of condensing water increased during Periods D and E.

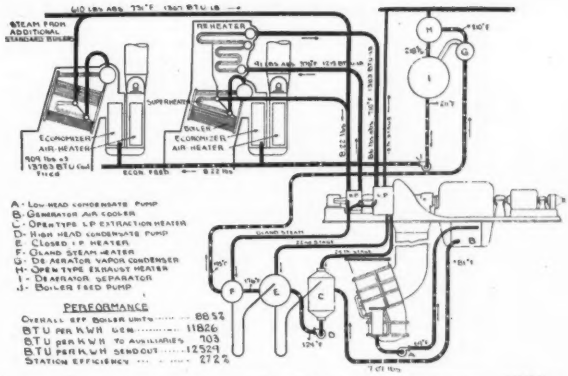

REHEATER
SUPERHEATER
ECONOMIZER AIR HEATER
BOILER ECONOMIZER AIR HEATER
A - Low head condensate pump
B - Generator air cooler
C - Open type L.P. extraction heater
D - High head condensate pump
E - Closed I.P. heater
F - Gland steam heater
G - De aerator vapor condenser
H - Open type exhaust heater
I - Deaerator separator
J - Boiler feed pump
PERFORMANCE
Overall eff. boiler units 88.5%
BTU per KWH Gen. 11826
BTU per KWH to auxiliaries 703
BTU per KWH send out 12529
Station efficiency 27.2%

FIG. 1. PERFORMANCE DIAGRAM FOR NOVEMBER, 1926, COLUMBIA POWER STATION

Period F. Number 2 turbine unit shut down for work on blading.

Period G. Number 2 turbine operated with two stages of blading cut out in low-pressure unit.

Period H. Number 2 turbine shut down to reblade two stages in low-pressure unit. Steam pressure No. 1 unit increased to 575 lb.

Period I. October 1, 1926. Both turbine units were

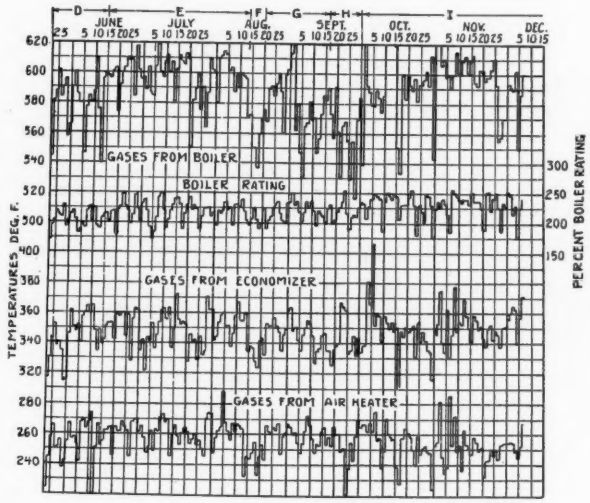


CHART 4. VARIOUS GAS TEMPERATURES FROM MAY 23 TO DEC. 7, 1926. REHEAT PUT ON BOTH UNITS IN PERIOD D

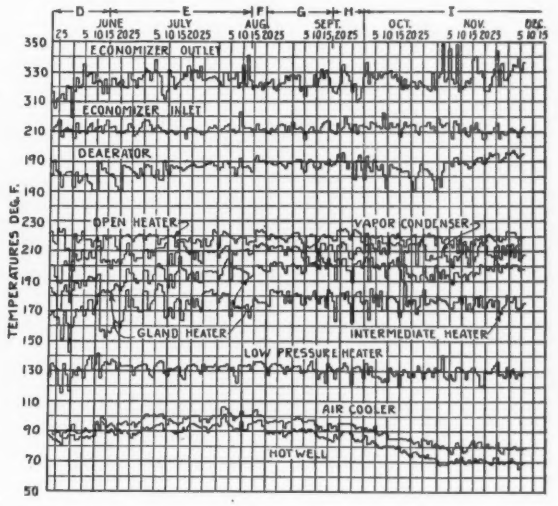


CHART 5. WATER TEMPERATURES, HOTWELL TO BOILER, FROM MAY 23 TO DEC. 7, 1926

TABLE I. GENERAL PLANT DATA FOR 1926, COLUMBIA STATION, SHOWING MONTHLY TOTALS OR AVERAGES

1926	Total Kw-hr. Gen.	Total Kw-hr. S. O.	Total Kw-hr. Aux. Power	% Station Power	B.T.U. Coal as Fired	B.T.U. per Kw-hr. Gen.	B.T.U. per Kw-hr. S. O.	Lb. Coal per Kw. Gen.	Lb. Coal per Kw. S. O.	Station Load Factor	Station Water Rate	Station Thermal Eff.	% Make-up Water	Kw-hr/Ton Coal from Barge to Pulv. Bunkers
Jan.	12399200	11095000	1304200	10.5	13890	16876	16835	1.21	1.35	77.5	10.8	18.1		
Feb.	12207300	11027000	1180300	9.6	13982	16069	17757	1.15	1.27	85.4	11.6	19.2		
March	15646500	14228000	1418500	9.0	14055	15601	17287	1.11	1.25	40.3	11.3	19.75		
April	22236200	20776900	1459300	6.5	14082	12589	13560	.894	.963	65.8	9.25	25.18		
May	23919400	22249400	1670000	6.9	14026	12763	13675	.91	.975	48.8	9.15	25.05		25.32
June	37513600	35169300	2344300	6.2	13972	12309	13119	.881	.939	56.7	8.05	26.02		22.29
July	39089000	36590000	2499000	6.3	13979	12440	13279	.89	.95	58.6	8.31	26.0		22.10
Aug.	37994200	35497300	2496900	6.5	13828	12638	13523	.914	.978	58.6	8.45	25.21	1.85	22.02
Sept.	34879700	32548700	2331000	6.6	13754	12873	13809	.936	1.004	56.0	8.60	26.55	1.70	20.90
Oct.	44907300	42469500	2567000	5.7	13803	11939	12657	.865	.917	64.5	7.89	27.0	1.65	21.71
Nov.	43753100	41347600	2405500	5.49	13783	11826	12529	.858	.909	65.4	7.78	27.3	1.50	22.13

TABLE II. DATA ON TURBINE OPERATION FOR 1926, INCLUDING EXTRACTION HEATERS AND CONDENSER

1926	Total Service Hours	Cap. Factor	High Pressure Turbine				Low Pressure Turbine		Temp. Condensate Deg. F.					Barometer Ins. Hg.	Vacuum Abs. Press. Ins. Hg.	Turb. Water Rate	Condenser Circulating Water			
			Steam Press. at Throttle	Steam Temp. at Throttle	Steam Press. Out	Steam Temp. Out	Steam Press. Inlet	Steam Temp. Inlet	Hot Well	Gen. Air Cooler	Low Stage Heater	Inter. Stage Heater	Gland Leakage Heater				In Temp.	Out Temp.	Gal. Per Min.	Heat Transfer
Jan.	723.5	36.	508	664					56	61	120	137	168	29.65	.67	10.5	33	44	30900	164
Feb.	672#	40.5	509	680					55	61	117	154	180	29.59	.61	11.3	36	46	38600	252
March	848	41	510	679					57	65	119	162	184	29.64	.64	11.1	38	48	38400	200
April	786	60.3	547	692					67	75	125	166	184	29.60	.70	9.19	47	58	43700	335
May	899.5	59.9	551	695	72	365	65	698	84	88	126	161	181	29.58	1.13	9.06	67	78	40300	399
June	1305	58.1	555	684	80	358	71	719	88	93	132	166	187	29.58	1.37	7.97	73	82	48600	392
July	1215.5	56.5	555	699	76	375	66	712	92	97	131	177	194	29.53	1.62	8.24	78	86	57000	458
Aug.	1151.5	56.7	568	693	80	377	70	693	91	100	131	176	198	29.66	1.67	8.39	76	86	50800	403
Sept.	1040.5	53.3	575	686	81	380	70	676	87	96	130	178	204	29.69	1.46	8.52	74	82	65400	419
Oct.	1256.0	57.08	579	702	76	389	67	705	78	87	130	176	197	29.60	1.06	7.88	61	70	56000	362
Nov.	1209.0	57.4	578	712	77	395	68	708	69	81	129	176	195	29.72	.87	7.67	46	58	41800	271

TABLE III. OPERATION OF STANDARD BOILERS AT COLUMBIA FOR 1926

1926	Hours Operation				Steam		Temp. Feed Water Deg. F.				Temp. Gases Deg. F.		Temp. Air Deg. F.			% Boiler Rating	Eff. 24 Hr. Boiler Econ. Heater, Etc.	Act. Evap. per Lb. Fuel	Fact. Evap. of Boiler	Fact. Evap. of Boiler Econ. Super.	Equiv. Evap. B. & E. per Lb. Fuel
	On Line	On Bank	In Service	% Bank to Service	Press.	Temp.	Vapor Cond.	Open Heater	Deaerator	Econ. In	Econ. Out	Boiler In	Econ. Outlet	Air Heater Outlet	Heater Inlet	Heater Outlet	Prim. Air					
Jan.	1562	177	1740	11.0	508	670	183	201	192	193	325	559	318	244	78	257	253	193	82.0	9.64	1.078	1.207	11.74
Feb.	1358	56	1415	4.1	509	680	190	217	203	205	324	585	335	253	76	258	247	219	83.8	9.86	1.085	1.208	11.91
March	1695	76	1771	4.2	511	682	200	222	208	206	319	597	347	255	78	230	243	229	83.0	9.93	1.090	1.207	11.98
Apr.	2076	148	2224	7.1	547	689	196	223	201	208	323	590	341	251	96	225	254	229	85.4	10.29	1.087	1.206	12.40
May	2183	147	2331	6.1	565	692	197	216	200	207	318	575	329	247	99	221	251	224	85.9	10.3	1.092	1.207	12.43
June	2205	268	2474	10.8	585	690	206	218	200	212	322	589	353	260	106	236	255	213	86.5	10.4	1.087	1.201	12.49
July	2364	236	2600	10.0	591	702	207	216	206	209	327	593	349	260	112	242	260	214	86.3	10.3	1.087	1.209	12.45
Aug.	2419	329	2749	11.9	595	713	210	218	206	212	322	592	348	257	112	242	263	215	86.2	10.4	1.080	1.204	12.52
Sept.	2225	124	2359	5.2	595	706	211	223	207	211	321	570	339	254	108	233	250	222	86.1	10.11	1.094	1.208	12.21
Oct.	2415	369	2784	13.6	613	727	210	221	203	215	332	589	345	256	101	232	246	234	87.76	10.24	1.104	1.220	12.49
Nov.	2304	353	2657	13.6	615	731	210	218	211	210	324	594	350	248	92	230	250	233	89.4	10.3	1.105	1.224	12.72

TABLE IV. REHEAT BOILER OPERATION AT COLUMBIA, 1926

1926	Hours Operation				Steam		Deg. F. Feed Water		Deg. F. Temp. Gases				Deg. F. Temp. Air			Reheat Coils				% Rating of Std. Boiler	Eff. 24 Hr. of Entire Unit	Tot. Heat Absorb. for Lb. Coal	% Tot. Abs. in Reheat	% Tot. Abs. in Blr. Econ.
																Inlet		Outlet						
	On Line	On Bank	In Service	% Bank to Service	Press.	Deg. F. Steam	Econ. Inlet	Econ. Outlet	Std. Boiler Out	Reheat Coils Out	Econ. In	Air Heater Out	Heater In	Heater Out	Prim. Air	Steam Press.	Steam Temp.	Steam Press.	Steam Temp.					
May	130	4	134	2.9	570	695	207	359	1312	698	554	263	106	251	284	69	365	68	698	302	83.9	11773	31.3	68.7
June	954	38	992	3.8	585	699	212	353	1367	625	599	285	112	267	289	76	358	75	719	415	86.1	12031	39.7	60.3
July	1025	25	1050	2.4	585	697	212	355	1395	654	595	268	114	247	270	72	375	70	712	397	91.0	12704	32.6	67.4
Aug.	966	26	992	2.7	590	681	212	353	1359	672	594	274	112	252	272	76	377	73	693	380	91.5	12695	36.6	63.4
Sept.	634	29	663	3.4	595	665	212	341	1354	685	597	288	114	250	266	76	380	74	676	386	87.8	12083	33.1	66.8
Oct.	1127	49	1176	4.17	605	665	217	350	1365	719	596	278	102	247	256	73	389	70	705	399	87.6	12100	33.4	66.6
Nov.	1126	23	1149	2.0	620	685	213	355	1343	691	607	263	92	246	257	74	395	71	708	398	87.2	12020	33.0	67.0

TABLE V. DATA ON COAL PULVERIZING EQUIPMENT AT COLUMBIA FOR 1926, SHOWING FINENESS, MOISTURE AND POWER CONSUMPTION

1926	Pulv. Coal % Fineness Mesh					Daily Sample % Moisture of Coal			Total Mill Hours	Capacity Tons/Hr. Mills	Total Drier Hours	Capacity Tons/Hr. Driers	% Coal Burned in Driers	Kw-hr. Per Ton Coal in P.H.					
	40	50	100	150	200	To Drier	To Mills	Storage Bunker						Milled	For Air Comp.	Wgh. Bin Pumps	Small Group	Total with Air	Total No Air
Jan.	99	95	85	73	63	3.4	1.8	.86	1194	6.3	385	19.8	1.98						
Feb.	99	96	86	74	64	3.21	1.7	.78	1037	6.8	346	20.4	1.02						
March	99	96	85	75	64	3.36	1.8	.84	1207	7.5	408	22.3	.88						
April	99	96	85	75	64	3.26	1.84	.90	1361	7.3	314	30.8	.63						
May	99	96	85	76	63	3.69	1.94	.95	1531	7.2	361	30.5	.62	15.5	5.0	.75	2.81	24.06	19.06
June	99	97	86	77	65	4.0	1.77	.86	2303	7.2	629	26.4	.73	14.96	2.28	.76	2.68	20.70	18.41
July	99	97	87	78	69	3.87	1.67	.70	2505	6.9	686	25.3	.58	15.65	2.27	.70	2.60	21.22	18.95
Aug.	99	97	87	78	69	4.13	1.69	.66	2339	7.4	696	24.8	.70	15.17	2.26	.80	2.67	20.90	18.64
Sept.	99	97	88	78	68	4.36	1.75	.70	2044	8.0	587	27.8	.92	14.05	2.39	.57	2.39	19.40	17.01
Oct.	99	97	87	79	69	4.10	1.79	.77	2337	8.1	678	28.6	.70	14.45	2.54	.64	2.61	20.24	17.70
Nov.	99	98	90	83	70	4.64	1.81	.84	2494	7.5	744	25.2	.95	14.68	2.02	.65	3.06	20.41	18.39

TABLE VII. TABULATION OF DATA ON STANDARD BOILERS BY DAYS FOR NOVEMBER, 1926, SHOWS HOW DAILY RECORDS ARE KEPT ON ALL EQUIPMENT

Nov.	Hours Operation: On Line	On Bank	In Service	% Bank to Service	Steam: Drum Press.	Deg. F. Temp.	Deg. F. Temp. Feed Water: Vapor Cond.	Open Heater	Deaerator	Econ. Inlet	Econ. Outlet	Deg. F. Temp. Gases: Boiler Outlet	Econ. Outlet	Air Heater Outlet	Deg. F. Temp. Air: Heater Inlet	Heater Outlet	Prim. Air	% Boiler Rating	Eff. 24 Hr. Boiler Econ. Heater, Etc.	Act. Evap. per Lb. Fuel	Fact. Evap. of Boiler Supt.	Fact. Evap. of Boiler Econ. Supt.	Equiv. Evap. B. & W. per Lb. Fuel
1	85	11	96	11.4	609	739	206	220	200	219	326	620	346	256	97	229	245	225	90.6	10.5	1.110	1.220	12.81
2	85	11	96	11.4	608	668	206	219	193	215	330	633	353	255	96	229	248	233	88.7	10.32	1.104	1.222	12.61
3	84	12	96	12.0	612	727	210	216	204	214	324	618	342	252	93	227	243	226	91.2	10.55	1.105	1.216	12.83
4	84½	11½	96	12.0	610	730	207	218	209	214	323	610	340	245	94	232	242	241	87.2	10.18	1.105	1.222	12.45
5	85	11	96	11.4	609	725	206	219	209	218	327	598	331	237	88	234	251	229	89.2	10.35	1.106	1.220	12.63
6	73	25	98	25.5	608	730	213	217	208	212	318	603	331	248	98	278	248	214	89.7	10.35	1.110	1.226	12.69
7	48	0½	53½	15.9	608	730	199	212	207	208	326	590	331	238	81	221	240	187	87.0	10.00	1.105	1.230	12.30
8	72	9	87	10.3	609	734	219	212	217	217	322	600	346	255	97	235	251	253	89.0	10.50	1.105	1.215	12.76
9	82½	12½	96	14.1	611	730	214	218	212	212	318	602	349	254	89	239	252	240	92.5	10.63	1.110	1.222	12.99
10	82½	13½	96	14.1	612	730	206	218	208	209	317	600	348	249	78	229	238	237	88.3	10.18	1.124	1.225	12.44
11	82½	13½	96	15.0	614	733	208	215	209	210	319	600	353	253	83	239	246	237	89.2	10.25	1.110	1.222	12.56
12	85	11	96	11.5	612	734	214	216	209	212	320	609	363	256	88	236	261	234	87.2	10.1	1.110	1.222	12.35
13	69½	17½	87	20.1	616	729	206	213	208	208	324	612	369	263	86	238	254	240	91.5	10.6	1.115	1.222	12.93
14	37½	11	48½	22.7	603	718	199	210	205	207	322	600	358	253	104	224	258	238	86.0	10.15	1.110	1.220	12.32
15	82	14	96	14.5	612	731	215	216	206	214	326	610	351	251	93	239	256	231	87.5	10.2	1.112	1.220	12.43
16	82	14	48	29.2	607	731	204	214	208	208	322	613	343	247	78	234	249	250	87.4	10.1	1.110	1.224	12.32
17	82½	13½	96	15.0	605	729	207	218	211	214	330	594	356	258	92	241	259	233	89.8	10.42	1.098	1.222	12.71
18	82½	12½	92	14.7	604	724	214	217	212	211	329	592	355	255	86	230	254	236	88.9	10.40	1.106	1.225	12.69
19	82½	12½	96	14.1	604	730	216	220	212	210	330	603	349	249	85	224	247	237	88.2	10.32	1.101	1.225	12.59
20	71	14½	85½	17.0	603	728	214	216	209	205	326	602	351	251	94	231	251	227	84.2	9.9	1.107	1.226	12.08
21	44½	7	51½	13.6	615	725	214	216	207	205	317	595	344	252	96	225	260	190	89.5	10.4	1.111	1.228	12.69
22	76½	12	88½	13.6	604	732	206	221	212	210	317	598	338	243	94	236	244	249	86.0	10.0	1.116	1.225	12.25
23	84	12	96	12.5	605	734	207	220	215	209	321	598	350	243	85	232	245	251	91.0	10.45	1.110	1.227	12.81
24	109	4½	113½	3.9	597	737	206	219	213	210	327	603	353	250	88	229	245	221	87.6	10.25	1.108	1.228	12.59
25	47	6	53	11.3	595	747	213	217	214	212	332	610	348	246	89	231	252	240	88.6	10.2	1.116	1.226	12.53
26	101½	1½	103	14.5	601	746	214	220	215	211	327	582	349	250	100	238	250	248	88.5	10.1	1.118	1.225	12.50
27	72½	20	92½	21.4	599	732	208	216	210	206	320	585	346	244	96	226	249	224	87.3	10.2	1.112	1.230	12.52
28	46	9½	55½	17.1	595	733	213	218	211	210	326	557	338	253	100	230	249	183	89.4	10.35	1.092	1.230	12.69
29	90	11	101	10.9	603	736	207	218	212	210	325	592	352	256	101	242	251	235	91.0	10.55	1.112	1.230	12.95
30	88½	14½	103	14.1	609	732	214	223	216	208	324	570	351	254	106	226	262	226	85.4	9.9	1.108	1.228	12.22
Total & Average	2304	353½	2657½	13.6	615	731	210	218	211	210	324	594	350	248	92	230	250	233	89.4	10.3	1.105	1.224	12.72

operating complete with full reheat. All work on tests and changes to station equipment were finished.

Accompanying tables show all pertinent operating data for the year by months. These tables are compiled from the monthly operating tables, which in turn show all operating conditions by days. Table VII is shown as a typical example of the way these tables are kept; this shows boiler operating data, while other tables are kept showing general data, turbine operation, standard boilers, reheat boilers and pulverizer house and coal-handling equipment by days.

All these records are plotted as shown. Charts 4 and 5 show portions of the yearly plat of various water and gas temperatures which are interesting if examined in connection with variations of station performance during the same period. Data on temperatures of primary and secondary air, steam temperatures to turbine and reheat boilers together with data on pulverized coal, are plotted in the same way but are not shown here.

TABLE VI. DATA FOR 1926 ON COAL HANDLING EQUIPMENT AT COLUMBIA

1926	Daily Coal Analysis: B.T.U. Dry	B.T.U. As Fired	% Moisture	% Ash	Kw-hr. Per Ton Coal Handled: River Hoist	Unload. Tower	Crusher House	Total Yard	Tons Coal in Storage	Tons Coal Received
Jan.		13890		7.95					12143	7350
Feb.	14100	12982	.94	7.70					21382	16300
March	14174	14055	.84	7.49					26987	14738
April	14210	14082	.90	7.38					43114	25825
May	14138	14026	.93	7.62	.21	.19	.82	1.86	40024	8826
June	14280	13959	.86	7.80	.34	.19	1.04	1.58	38347	12869
July	14077	13979	.70	7.81	.19	.17	.52	.88	35885	21503
Aug.	13919	13822	.66	8.41	.36	.18	.59	1.12	37682	20129
Sept.	13851	13754	.70	8.85	.39	.15	.96	1.50	36865	16418
Oct.	13991	13803	.85	9.10	.31	.14	1.02	1.47	52393	33502
Nov.	13927	13785	1.06	9.19	.33	.32	1.07	1.72	43094	12440

Coal weights are obtained by three methods: first, by railroad weights; second, by weightometers on belt conveyors and third, by pulverized coal weigh-bins hung on Fairbanks scales. By the first method, that of railroad weights, barges are loaded from railroad cars at the river shipping point, and these weights are used for billing purposes.

The operation during the month of October showed an economy of 12,657 B.t.u. per kw-hr. net sendout. The November economy was 12,529 B.t.u. per kw-hr. sendout and for December, 12,495 B.t.u. Detailed operating data for December were not compiled in time to include in this article.

Fire Fighting Equipment in Winter

HAND PUMP extinguishers, water barrels, pails, hose, and other fire fighting apparatus should have renewed attention now that freezing weather has come to stay. In this connection it is well to remember that the addition of calcium chloride (commercial, 75 per cent) is perhaps the best means for making an anti-freeze solution for use in such equipment. The strength of the solution will, of course, depend upon the temperatures to which the apparatus is subjected, the following table, from the Bureau of Standards, being a proved guide in this respect:

PROPORTIONS FOR 2.5 GAL. OF SOLUTION

Temperature at Which Solution Will Freeze	Water Gal.	Calcium Chloride	Specific Gravity
+ 10 deg. F.	2¼	5 lb.	1.139
Zero	2¼	6¼ lb.	1.175
— 10 deg. F.	2	7 lb. 6 oz.	1.205
— 20 deg. F.	2	8 lb. 6 oz.	1.228
— 30 deg. F.	2	9 lb. 2 oz.	1.246

The strength of a solution may be tested by the use of a hydrometer which will indicate the specific gravity, a necessity where the solution has been standing for some time or where calcium chloride not freshly opened is being used. Because calcium chloride solutions weaken with time and exposure, all containers should be provided with close fitting covers. In addition they should be coated on the inside with asphaltum paint and have the addition of about a tablespoonful of lime to prevent acidity and subsequent corrosion.

Principles of the Pneumatic Turbine Governor

IN THE ARTICLE "Principles of Steam Turbine Governors," which appeared in the September 15, 1926 issue, brief mention was made of the pneumatic-type governor, but because of the general nature of that article, the details of this governor were not described. This governor, which is made by the Ridgway Dynamo & Engine Co., possesses a number of interesting features which will be described in the present article.

This governor, like practically all other types of speed governors, depends for its action on centrifugal

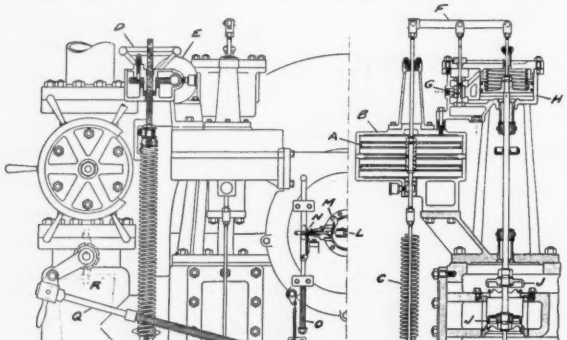


FIG. 1. HIGH-PRESSURE GOVERNOR AND EMERGENCY TRIP

force. The centrifugal force is that set up in a suitable enclosing housing by a simple radial-bladed fan, mounted on the end of the main shaft. The static air pressure generated at normal speed by this fan is approximately 0.63 lb. per sq. in. for a 3000-kw. turbine.

This pressure is conducted to the under side of two freely-floating aluminum pistons A, mounted in tandem in a cylinder B (see Fig. 1), and opposed by the synchronizing spring C, the tension of which can be varied either by handwheel D or by means of a synchronizing motor E from the switchboard, to change the turbine speed. The upper sides of the aluminum pistons are exposed to atmospheric pressure.

The upper end of the air piston rod is connected through a sliding block to one end of the compensating lever F, to the center of which is suspended a small pilot valve G, movement of which admits oil at a pressure of 30 lb. from the main lubricating system either to the top or bottom of the operating cylinder H. Movement of the operating piston controls the position of the steam admission valves J and K, and hence the flow of steam to the first-stage nozzles. A heavy compressed spring above the piston serves to close the valves independently of the speed, in case the oil pressure should fail.

To illustrate the operation of the governor, assume that the load increases, causing a small drop in speed, and hence a reduction in air pressure proportional to the square of the speed change. This pressure drop causes the air pistons to move downward slightly, which lowers the pilot valve and admits oil to the bottom of cylinder H, and opens the steam valves slightly, admitting more steam to carry the increased load. The movement of the operating piston restores the pilot valve to its normal position, thus preventing over-travel of the steam valves and consequent hunting in speed. The action caused by a decrease in load is similar but in the opposite direction. Movement in either direction is extremely rapid and positive.

The interesting feature of this governor is the entire absence of any mechanical linkage between the turbine shaft and the nonrotating elements of the governor. These parts are all replaced by a flexible column of air between the fan and air pistons.

The emergency overspeed governor is independent of the main governor. The speed element consists of a spring-loaded centrifugal bolt L in the fan hub, which flies out at 10 per cent above normal speed, striking curved finger M, which trips the primary latch N, allowing drop rod O to strike the secondary latch P with a hammer blow. The releasing of latch P causes the trip rod Q to move to the right, closing butterfly valve R, as shown in Fig. 1, or on the larger turbines, tripping a combined trip and throttle valve, as shown in Fig. 2.

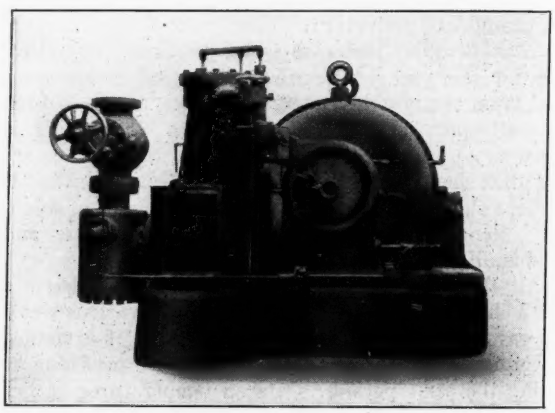


FIG. 2. VIEW OF END OF TURBINE SHOWING COMBINED TRIP AND THROTTLE VALVE

On the smaller sizes of Ridgway turbines the valve arrangement is as shown in Fig. 1, the upper main valves, of the balanced double-beat poppet type, controlling the flow to the main section of first-stage nozzles, designed for about 80 per cent of full load. The lower piston valve opens at this load, and feeds an additional arc of first-stage nozzles, carrying up to a little more than full load. A hand-operated bypass valve is furnished in this case for overloads.

The larger sizes have a somewhat different valve arrangement, not shown in Fig. 1. The main valve is of the double-beat poppet type, carrying up to 60-per cent load. A second valve of the piston type, with two rows of ports, is mounted on the same stem as the main valve. At 60-per cent load the first ports are opened, feeding a second arc of first-stage nozzles up to 80-per cent load. At this point the second ports open, bypassing steam to an arc of nozzles in the second stage and carrying up to the required overload.

The advantage of the latter valve arrangement is to give a flatter water rate curve at fractional loads, by virtue of the reduced throttling loss as compared to a single-valve arrangement.

Relation of Stokers to Boilers

EFFECT OF STOKERS ON EFFICIENCY. DIFFICULTIES AND REMEDIES AT HIGH RATINGS. BY W. A. SHOUDY*

APPARATUS for the mechanical feeding of coal to a boiler furnace was developed primarily for the purpose of reducing human labor. The reduction of labor was not so great as expected until coal conveying apparatus replaced the coal passer but the mechanical stoker gradually gained popularity because, by the elimination of frequent opening of the fire doors, excess air was reduced and furnace efficiency increased—in common parlance, the boiler efficiency was improved, although the boiler had nothing to do with the improvement.

Application of forced draft to the chain grate stoker and the development of the underfeed stoker and its operation with forced draft, made continuous operation possible at the higher rates of combustion because the extraordinary human effort was eliminated and cleaning of fires could be carried on without serious interruption to service. Length of grate was no longer limited by the distance that a man could throw coal with a shovel, hence stoker grates were soon extended beyond the length of the flat grate and a larger total weight of coal could be burned without increasing the rate of combustion per square foot of grate surface. More careful design of the stoker grate so as to get a more uniform distribution resulted in increased rates of combustion without sacrifice of furnace efficiency but rather, in most cases, an actual improvement.

Since the heat absorbing surface (the boiler surface) was not increased, higher rates of transmission were necessary and were obtained but at the cost of increasing exit gas temperature, i. e., at a reduction of heating surface efficiency; however, boiler tests showed in many cases an improved combined boiler and furnace efficiency. It should be obvious that this improvement was due to improved furnace efficiency. The increasing length of stokers rapidly pushed back the bridge wall until it became the rear wall of the boiler setting. The tubes were then lengthened to give a larger heat absorbing surface and the stoker again lengthened to meet the longer tubes. With such combinations, operation at ratings of 300 per cent was not unusual. These high ratings were obtained at a sacrifice in combined efficiency because of the higher exit gas temperature. Additional heat absorbing surface was added as economizer or air heater surface which increased the combined efficiency.

INCREASE IN BOILER CAPACITY

Additional boiler surface was next added by increasing the height of the boiler thus reducing the work of the economizer or air heater and in some cases eliminating them where the highest combined efficiency was not justified by use factor or fuel cost. For many years the preponderance of inclined straight tube boilers were built with 14 tubes counted vertically. Additional surface was obtained by increasing the number of tubes vertically. This gave a cheaper boiler per square foot of surface but no larger stoker could be fitted under it than a 14-high boiler. Consequently, no higher horsepower or steam output could be developed nor could the stoker be operated at a higher rate of combustion or higher furnace efficiency. Because the heating surface was larger the exit gas temperatures were lower, hence the combined efficiency of the higher boiler exceeded that for the 14-high boiler for the same steam output.

The 20-high boiler or its equivalent is quite common and a few 24 tubes high have been in operation for a sufficient time to prove their worth. A 4-in., 20-ft. tube boiler, 18 tubes wide, will have a heating surface depending upon the number of tubes high approximately as follows: 14-high, 6200 sq. ft., 20-high, 8400 sq. ft. and 24-high 10,000 sq. ft. The same size stoker will fit under each of these boilers because the floor space is the same.

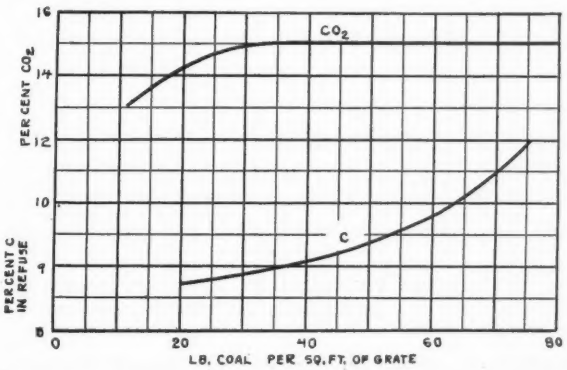


FIG. 1. VARIATION OF PER CENT OF CO_2 AND PER CENT OF CARBON DISCHARGED IN ASH WITH RATE OF COMBUSTION

If therefore, a stoker is selected for the first boiler which will permit of operation at 400 per cent rating, 2480 hp. will be developed. If the first boiler is replaced by the 20-high and neither the coal nor the stoker changed, no greater output can be obtained and the maximum rating for this combination will be 295 per cent. If the 24-high is next substituted only 248 per cent rating can be obtained. Since the furnace conditions are the same in all three installations, the furnace efficiency will be the same for all, but the combined efficiency will be the highest with the 24-high installation. The heat liberated by the stoker is the same for all three but the 24-high boiler presents a larger heat absorbing surface and a lower exit gas temperature. If a larger stoker is installed with the larger boiler it might be operated at 300 per cent rating developing 3000 hp. but that same stoker under a 14-high boiler would deliver the same horsepower but the boiler would operate at 485 per cent rating.

"Per cent of rating" where applied to present day boiler operation is a term of little value unless the design of the boiler is specified and at times is even misleading. This is particularly true, for example, when comparison is attempted of the reports of the Hell Gate boilers and those of the new Interborough boilers. The Hell Gate

*Advisory Engineer, General Engineering and Management Corp. From a paper read at Annual Meeting, American Society of Mechanical Engineers, New York City, December 7, 1926.

boiler is a 3-in. tube boiler whose surface approximates a 14-high, 4-in. tube boiler. The Interborough boiler is 24 tubes high. The ratio of heating to grate surface in the latter is, therefore, approximately double that of the former if the same rating is used. The tests reported by Mr. Reynolds, showing 343 per cent rating, represent a furnace condition approximating 585 per cent rating on the Hell Gate boilers. Whereas the highest reported rating on the Hell Gate boilers, 590 per cent, is the equivalent of 295 per cent rating on the Interborough boiler.

This comparison is not made for the purpose of drawing any conclusion as to the relative merits of the two installations but merely to show how little value are comparisons on the basis of per cent of rating.

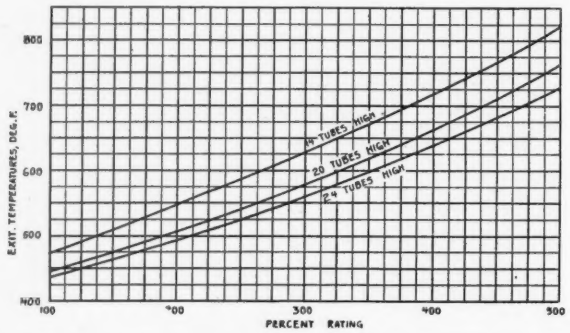


FIG. 2. EXIT GAS TEMPERATURES UNDER DIFFERENT PER CENT BOILER RATINGS

Intelligent comparison can be made between two such widely separated installations by comparison of the stokers on the basis of pounds of coal or B.t.u. liberated per square foot of grate area (actual or projected) and the boilers on the basis of evaporation per square foot of heating surface or per foot front of boiler furnace. Until someone can develop an all inclusive term, we must make our comparison on such a basis. The author hopes that the term "per cent of rating" may be eliminated from the steam engineers' vocabulary.

In stationary practice we have not reached the limit of evaporation for the steam boiler. This is shown by the higher rates obtained in marine boilers. If the boiler feed water is poor and the boiler design such as to provide satisfactory circulation there are apparently only minor operating difficulties experienced when operating boilers at high rates of evaporation. It is nevertheless common to hear of interruptions to service due to operation at "high ratings." This is so much the case that "high ratings" have been left to the central station and the industrial plant has generally kept to conservative operation. These ratings have not always been as conservative as the purchaser has expected. Because 14-high boilers have been successfully operated in industrial plants at 200 per cent rating, 20-high boilers have been installed for the same rating, yet the latter furnace condition is the same as for a 14-high boiler at 275 per cent rating. Unless the stoker and furnace are carefully selected for the high boiler, trouble may be expected, but not with the boiler.

Operating difficulties at high ratings are due to one or more of the following causes:

1. Impure feed water.
2. Poor circulation or insufficient steam liberating surface.
3. Restricted feed water supply.
4. Grate or stoker trouble.
5. Ash or clinker trouble.
6. Refractory trouble.

The first three can be foreseen and either eliminated before they occur or the boiler installations must be limited to conservative rate of evaporation. The last or furnace troubles cannot always be foreseen and are less easy to prevent but they can be minimized by careful engineering. They all vary with the coal and are so inter-related that they cannot always be separated and studied. Perhaps the major difficulty is with the impurities in the coal.

Operating difficulties almost never occur at low combustion rates. The rate at which trouble begins is almost invariably determined by the impurities in the coal. Before the type of stoker can be selected the character of the coal must be known.

1. The relative ease of ignition.

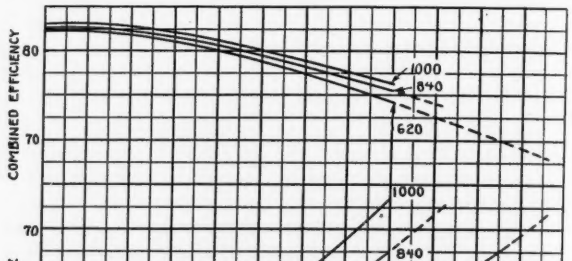


FIG. 3. EFFICIENCIES COMPARED WITH RATINGS WHEN EQUIPPED WITH SAME STOKER

2. The per cent of ash content.
3. The fusion temperature of the ash.

Each of these divisions may be subdivided still further though further subdivision is generally unnecessary.

Selection of Correct Boiler and Stoker

Selection of the correct boiler and stoker combination becomes one of selecting first the stoker and furnace and then selecting the best heat absorbing surface that price of fuel, draft, use factor and fixed charges will permit. The heat absorbing surface will be the boiler alone or with economizer and air heater, or with either. The size of the stoker will depend upon the quality of the coal and whether money can be spent for water or air-cooled walls. It is doubtful whether water-cooled walls can be justified for boilers smaller than 750 hp. except possibly to patch at the base of the bridge wall or when the fluxing of the ash is unusually severe. Without water cooling 60 lb. of coal per sq. ft. of projected grate area

should be the maximum for underfeed stokers. With complete cooling 75 lb. may be used but in either case 35 to 50 lb. should be the rate for best operation. Preheater air may improve these rates though complete data is lacking and higher rates cannot be counted upon at present. We must content ourselves with the heat saving by the preheater and the better behavior of the fuel with preheat.

With anthracite, 55 to 60 lb. should be considered a maximum and the best rates taken as 30 to 45 lb. The higher rates will give capacity but at the expense of loss of fine coal to the chimney. It is impossible completely to catalog all fuels. Before selecting a stoker the behavior of the local coal should be observed on another installation and the correct rate of combustion selected and the stoker proportioned accordingly.

For the purpose of illustrating the folly of selecting boilers solely on the basis of their respective performances at "per cent of rating," the author has included a brief study of boiler and stoker combinations for a plant to deliver 300,000 lb. of steam per hour from and at 212 deg. He has estimated the efficiencies of six different boiler and stoker combinations. In order that these efficiencies may be strictly comparable he has assumed one type of stoker namely the multiple retort underfeed stoker, provided with rotary ash discharge or clinker grinder. He has assumed a coal of 14,000 B.t.u. dry basis with 7 per cent ash.

Stoker Efficiency

It is impossible to plot a curve of furnace efficiency, but the efficiency of the stoker can be indicated quite clearly by the per cent of CO_2 and the per cent of carbon going out in the refuse. These assumptions are plotted as curves in Fig. 1. With low rates of combustion it is difficult to maintain low excess air, but at the higher rates a uniform per cent of excess air can be maintained with reasonably careful operation. The excess air loss is therefore high at low rates of combustion. As the rate of combustion increases it becomes increasingly difficult to keep down the per cent of carbon going out with the ash. The efficiency of the stoker is therefore low at low rates of combustion and at extreme rates of combustion, but reasonably flat over the intermediate rates. The assumed per cent of carbon in the refuse may be criticized as too low. It does not represent past practice but the author believes it represents what can be expected of a modern underfeed stoker.

Three types of boilers have been assumed, but all of these boilers have the same furnace width and length. They are as follows:

1. 620 hp., 14 tubes high.
2. 840 hp., 20 tubes high.
3. 1000 hp., 24 tubes high.

All of these boilers are 18 tubes wide with 20-ft. tubes. The expected exit gas temperatures for these three boilers are plotted in Fig. 2. For the purpose of simplicity as well as to obtain a more accurate comparison all losses listed in the boiler heat balance are assumed constant at all outputs except the losses due to carbon in the refuse and chimney losses.

Comparison is first made with each of these boilers equipped with a six-retort underfeed stoker having a projected grate area of 206 sq. ft. The efficiencies of these three boilers equipped with the same stoker are plotted in Fig. 3 against "per cent rating." The rate of combustion for each combination is also plotted. With the continuous dump or clinker grinder and rather complete water cooling of side walls, a maximum combustion rate of 75 lb. per sq. ft. of projected area may be expected. Under such conditions the 14-high boiler would deliver 640 per cent rating, the 20-high, 540 per cent rating and the 24-high, 490 per cent rating. With water-cooled walls we would not expect stoker troubles at these high rates because of the large size of stoker. We can,

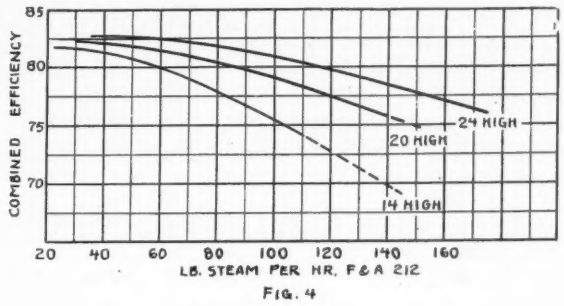


FIG. 4

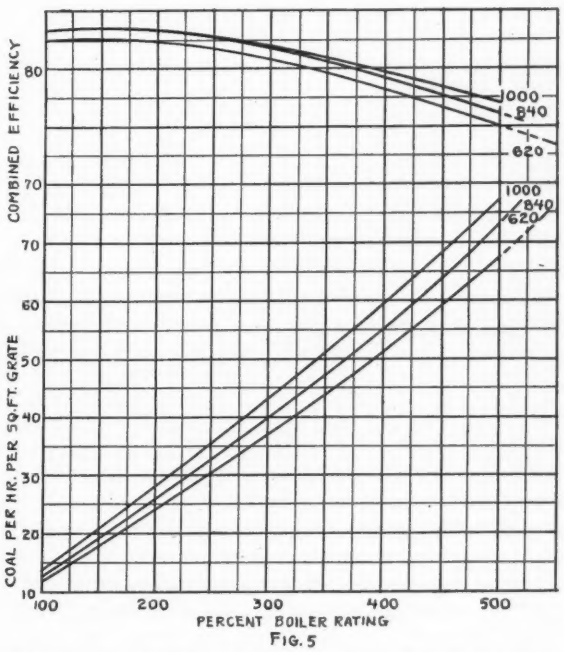


FIG. 5

FIG. 4. EFFICIENCIES COMPARED WITH STEAM OUTPUT
FIG. 5. EFFECT OF INCREASING NUMBER OF TUBES COMPARED WITH RATING

however, expect boiler troubles unless provision is made for a high rate of feed to the boiler as well as abundant steam liberating surface. Such boilers would also have to be operated with only the purest feed water.

Inasmuch as the assumed plant is of a relatively small size, it would hardly seem advisable to go to the expense of water cooling, in which case the rate of combustion might be kept to 60 lb. as a maximum with proportionately lower "per cent rating." The per cent rating mentioned above, of course applies only to short periods. The continuous maximum should be limited to about 50 to 55 lb. per sq. ft.

In Fig. 4 these combined efficiencies have been re-

plotted against steam output of boiler instead of rating. The curves as plotted in Fig. 3 show very little difference in efficiency but when replotted in Fig. 4 the differences are so apparent as to need no further discussion. The selection of the boiler, therefore, becomes merely that of determining whether the reduction in fuel per year will offset the increased fixed charges of the larger boilers.

Variations in plant loading throughout the year often require a larger number of boilers than the three mentioned above. The combined efficiencies have, therefore, been worked out for a plant with three, four and five boilers respectively. Inasmuch as stokers are made in standard sizes, it is impractical to get a combination with which there will be exactly the same proportion of heating surface and grate surface. The proportion is indicated by the following statement:

Boilers	Stokers
1. 3–1000-hp. 3000-hp. total	3–206-sq.ft., 618-sq.ft. total
2. 4– 840-hp. 3360-hp. "	4–184-sq.ft., 736-sq.ft. "
3. 5– 620-hp. 3100-hp. "	5–152-sq.ft., 760-sq.ft. "

The boilers are respectively 14 high, 20 high and 24 high. The combined efficiencies of these combinations have

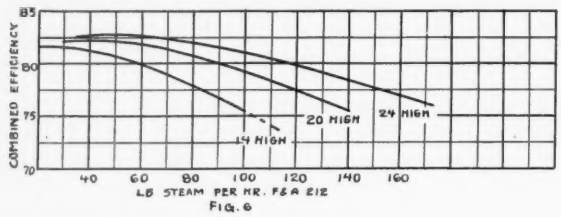


Fig. 6

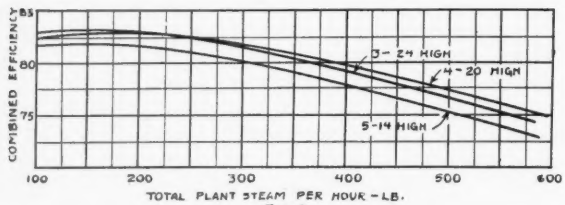


Fig. 7

FIG. 6. EFFECT OF INCREASING NUMBER OF TUBES COMPARED WITH STEAM OUTPUT

FIG. 7. EFFECT OF INCREASING NUMBER OF TUBES COMPARED WITH TOTAL PLANT OUTPUT

been plotted against rating in Fig. 5 and they are replotted against steam output per boiler in Fig. 6. Figure 6 also indicates that the 24-high boiler is the best selection; however, when these efficiencies are again plotted but this time against the total plan output, the 20-high boiler shows up the equal of the 24-high and the 14-high is only one point lower than either.

The reason for this condition is obvious when we note the total horsepower installed. Case 1 has the smallest total horsepower and the largest boilers; case 3 has the next largest horsepower but the smallest boilers and the largest grate area; case 2 has the largest horsepower and the middle size boilers, consequently case 1 operates at the highest rating, case 3 at the intermediate rating and case 2 at the lowest rating. The lower rating of case 2 offsets the lower exit temperature expected with the higher boiler, and case 3 has slightly lower efficiency because the 14 high type of boiler has a higher exit temperature than the 20-high for the same steam output.

Many other combinations might be worked out. If high overloads are not expected at this plant slightly smaller stokers might be selected. Narrow, but longer stokers might be installed in a five-boiler plant, using a higher boiler to get the same surface. This would work out a little more efficiently than the case selected. The exact answer cannot be worked out in such a way that it will apply to all boiler houses. The five-boiler combination would, of course, be the most expensive. There will be five settings to erect instead of three. Boilers and stokers would be approximately the same price, but the length of the boiler house will be greater, greatly increasing the cost of the project. The determination of the number of units will be settled, not by a comparison of boiler efficiency but by a comparison of the total cost of the project and by local conditions governing the number of boilers.

Enough data has been presented to show that the selection of the correct combination of stoker and boiler cannot be determined by rule of thumb methods, nor can it be based upon comparisons of operations at certain per cents of ratings. The selection must be made along the following steps:

1. Determine the number of boilers that the variations in load and local conditions demand.
2. Select a grate surface of sufficient size to permit of conservative combustion rates.
3. Determine the rate of evaporation that feedwater conditions will permit.
4. Select the most efficient heating surface that draft, coal costs and fixed charges permit.

Types of Automatic Hydro Plant Control

THERE ARE several methods of automatic operation and control of hydro plants based on (1) operation with fixed gate opening; (2) regulation of load with respect to head available, and (3) regulation of speed by a centrifugal governor. The selection of any specific type depends, of course, on the conditions of the system.

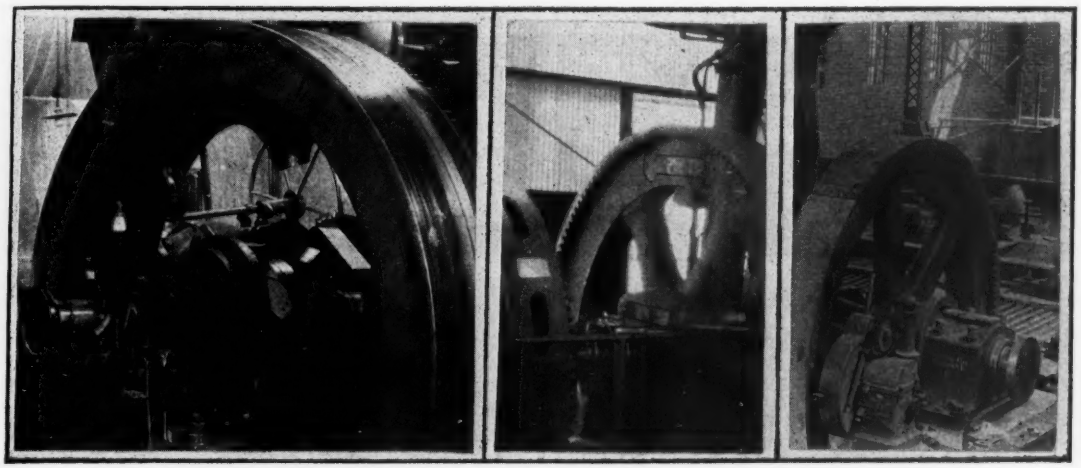
Oil pressure operated governors, for use with method (3) are often employed, the pressure being obtained by a pump connected through a transformer on the a.c. bus. This method can be used to lock out the station unless the oil pressure is high enough for good operation.

If brakes are provided, they may be operated by oil pressure or air pressure, the former applied by magnet valves or mechanical valves actuated by the water-wheel gates, the latter with magnet valves of the railway control type.

Main bearings can be protected by thermal relays which will shut down the unit if a bearing overheats.

Balanced relays protect against insulation failure by opening breaker and field switch. Overheating of windings is protected by thermal relays; field failure is caught by a time delay relay in series with the field. External short circuits are caught by overload relays or by using line voltage as an indication of trouble.

Initial starting for the automatic control may be obtained in one of the following ways: water level, system frequency, remote control by pilot wire, supervisory control over telephone circuit, manual operation of control switch, manipulation of a.c. line, time switch.



Poor Maintenance Methods Result in Accidents

PIONEERS IN DIESEL FIELD DID NOT HAVE ADVANTAGE OF EXPERIENCE WHICH MAKES MODERN ENGINE SAFE AND RELIABLE. BY J. J. MCDOUGALL

DESIGN AND CONSTRUCTION methods have a great deal to do with the proper performance of an oil engine. The present high state of development of the modern Diesel has not been reached without some trials and tribulations and a study of some of the accidents occuring to pioneers in this field is interesting.

Counterweights were once a source of danger and Fig. 1 (left) shows the result of such a failure. In this case the construction was very flimsy, depending entirely upon studs which broke with regularity. A much safer method is to use keyed or dovetailed joints. Generally when coming loose they gave some warning but occasionally flew through the roof or wall without notice. In this case, however, the weight fell into the pit where it was hit by the crank. The shaft was not broken but underwent severe strains although it was later used in another engine for several years.

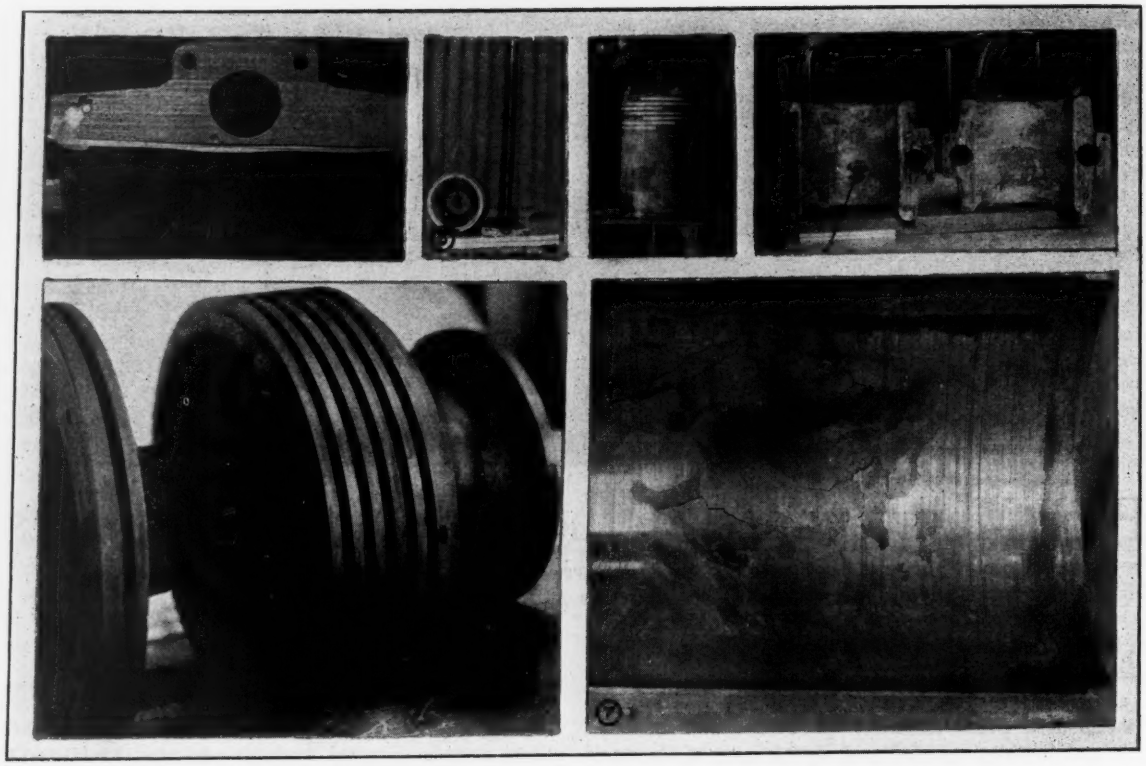
Defective flywheels will break a shaft, very similar to the break caused by misalinement. There is no doubt that the flywheel in Fig. 1 (right) was defective as the left-hand view at the top of the page showing the opposite side of the engine in Fig. 1, shows that the dropping of a similar flywheel into the pit would not break it. These flywheels, due to being cast in one piece were liable to have casting strains in them.

Poor methods of fastening flywheel to shaft allows it to wobble or become loose, putting the shaft under severe strain. Several methods are used to fasten the flywheel successfully, the efficiency of the key and shrink rings at the top of the page being shown by its undamaged condition after the rim of the flywheel had been torn entirely loose. The middle view shows the hub and rim of the wheel shrunk together with large links, no keying being used, while in the right hand view the hub is shrunk to the shaft with rings. Keys are eliminated so that in case of a sudden seizure the flywheel will slip on the shaft and not strip the spokes.

Connecting rod bolts are another source of danger. One horizontal four-cycle engine wrecked from this cause was repaired by the rods and put back into service only to throw a 5000-lb. weight into the flywheel which threw it over four other engines onto a work bench. Again the shaft was not broken but continued to give good service.

Journal bearings are not trouble-proof and practical men reject them when the babbit is loose in the shell

FIG. 1. ACCIDENTS TO EARLY-TYPE ENGINES CAUSED BY FAILURE OF COUNTERWEIGHT STUDS (LEFT) AND FLYWHEEL FAILURE (RIGHT)



FIGS. 2—7. VARIOUS FEATURES ILLUSTRATING POOR MAINTENANCE METHODS.

or poorly poured as they always fail under service and generally have to be renewed in an emergency. That is, they fail unexpectedly.

Figure 2 shows a crank bearing of this kind which fails much quicker than the journals. Sometimes a faulty bearing cannot be detected so easily by eye but the hammer test shows them up as a good bearing will ring but a loose one sounds like a cardboard box. Figure 7 shows a bearing that looked good but failed quickly, such bearings wear rapidly and of course result in misalinement of the shaft.

Even in the case of the two-cycle engine bearings should be kept to their minimum running clearance. It is sometimes claimed that in these engines the pressure on the bearings is always down so it thus does not matter how loose the bearings are. This may be true in normal conditions but in severe operating conditions, reversal of pressure occurs, which may be greater than the exhaust and suction strokes of the four-stroke engine; for instance, when the piston top was pulled off, as in Fig. 6.

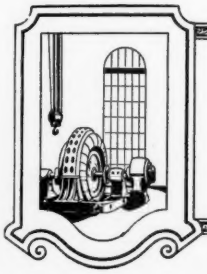
In this case the piston rings were improperly fitted and wore a shoulder about 2 in. below the top of the exhaust ports. This shoulder caused a knock each stroke and it was just a question of which would fail first, the piston rings in compression or the cast-iron piston in tension. Naturally the piston failed first but a new steel piston broke the rings until the bottom edges were beveled off and given the proper end clearance. The same result would have been obtained by grinding the liner if a grinder had been available.

When a piston starts to seize or when the rings are being broken by getting caught in the exhaust ports, the same things happens and if the bearings are loose they will be pounded out while the shaft will be put under a bending strain which will do it no good. Poor workmanship is in no small way responsible for many failures while, before heat treatments of metals had received such intensive study, unsuitable metals caused their share. Figure 3 shows a valve and cage of an early design made from unsuitable material which burned out after 40 hr. service. Typical piston packing failure of a two-cycle engine caused by poor fitting is shown in Fig. 4. But one of the seven rings remains complete, parts of the others passing out through the exhaust ports during six days' service.

Many Troubles Traced to Lubrication

Lubrication systems are not beyond causing trouble and Fig. 5 shows a burned-out crank bearing caused by dirty oil plugging up the oil hole. The bright spot shows where steel shell started to rub on crankpin. As the engine was quickly shut down the pin was only slightly scored. In cases where the engine is run long enough to score the pin severely it may require several days to get things straightened out. It never pays to take a chance with the shaft in such cases as the overheating may burn out the adjacent journal bearings, causing enough misalinement to break or severely overstrain it. This is only a small bearing about 12½ in. in diameter taking about 200 lb. of babbit and is given a normal clearance of 0.006 to 0.009 in. Even in these small bearings a heavy pound is heard in all parts of the plant. Larger bearings are of course proportionally worse.

There are of course so many factors entering into Diesel engine operation that they cannot be correlated or tabulated. Improved design, engineering and maintenance, however, are doing much to place this type of prime mover on a par with other machines in the matter of service and reliability.



ELECTRICAL MACHINERY FOR LIGHT AND POWER

Principles of the Mercury Arc Rectifier*

GROWING INTEREST IN MERCURY ARC RECTIFIERS REVEALS MANY NEW FACTS OF INTEREST. BY D. C. PRINCE†

MERCURY ARC rectifiers have been known for about 24 yr., but, in spite of the length of time which has elapsed, there are a great many things about them which are not understood with any degree of certainty. A good deal has, however, been found out, especially in the last few years and, since interest in rectifiers is growing, it may be worth while to go over some of the principal features so as to get a general idea of the rectifier and its problems.

Figure 1 represents a standard 50-amp., 150-v. mercury arc rectifier. This form is shown on account of its simplicity for purposes of explanation. It consists of an evacuated glass bulb containing in this case two main anodes composed of graphite located in the anode arms projecting at either side of the bulb; two auxiliary anodes also made of graphite lower down and on the front of the bulb; a starting anode made of mercury at the lower right, and a mercury cathode pool at the bottom.

In its barest essentials, the principle of operation is similar to that of the vacuum tubes used in radio reception, with which most people are now familiar. In a vacuum tube a filament is heated until the electrons in it have so much energy that they are able to break through the metallic boundary into the surrounding space. If the anode (plate) is positive, these electrons are attracted toward it and current flows. If the anode is negative with respect to the filament, the electrons will be drawn back upon the filament and no current can flow. Rectifier or check valve action is thus established, since current can be carried in one direction only. In the high vacuum rectifier the electrons filling the space between anode and filament produce a charge known as the "space charge" which tends to drive the electrons back. This causes a loss which becomes very high if it is attempted to draw considerable currents.

In the mercury rectifier, in place of the filament we have a small, bright, dancing spot called the "cathode spot" which is the source of the electrons. Electrons are drawn from this spot to the anodes when they are positive just as in the high vacuum tube but, when the anodes are negative, they do not constitute a source of electrons, so that no current can flow and rectification is obtained. There is some difference of opinion as to what occurs in this spot. The electrons proceeding from it strike neutral molecules of mercury vapor and ionize them, that is, one electron is removed from the molecule and the remainder of the molecule then has a positive charge. These positively charged molecules, called positive ions, are attracted toward the cathode and, since they are quite heavy, their striking represents considerable energy, and the spot where they strike is heated. There is thus some action analogous to the heating of a filament. In addition to this heating, the positive ions, being heavy, move slowly. A large accumulation of them near the mercury surface produces a high potential gradient which tends to draw electrons from the mercury surface at a lower temperature than that at which they would be able to leave it if there were no such strongly attractive force. The electrons drawn out ionize new molecules which heat the surface of the mercury and draw electrons from it, so that the process once started is self-continuing, provided the potential necessary to make the current flow is present. To start the spot in the first place, an arc is drawn by tilting the tube so that the mercury in the cathode makes contact with the mercury in the starting anode. The poten-

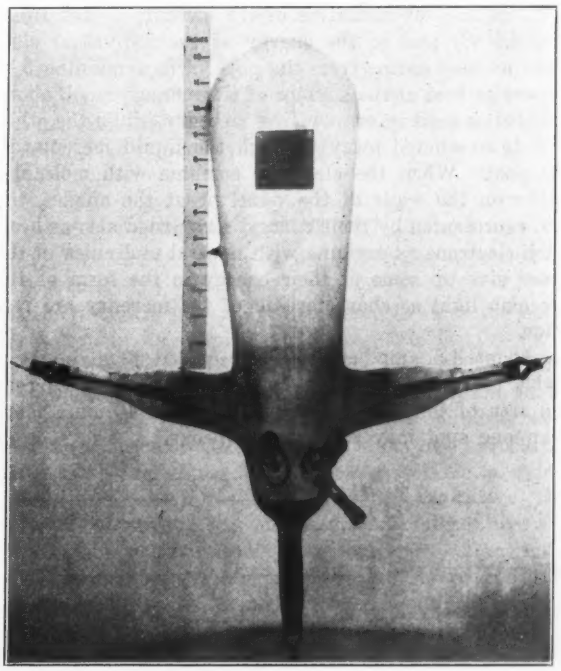


FIG. 1. MERCURY ARC RECTIFIER TUBE, 50 AMP. D.C., 150-V.

*Abstract of a paper presented before the American Institute of Electrical Engineers.

†Research Laboratory, General Electric Co.

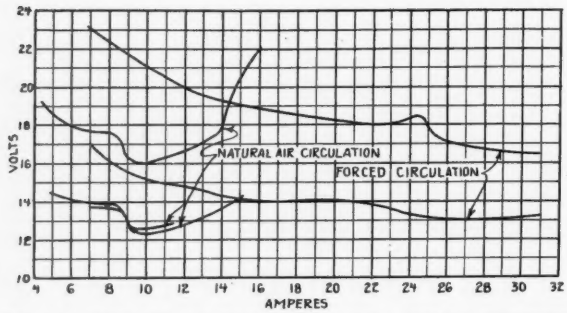


FIG. 2. FORM OF ARC DROP CURVE FOR A SMALL RECTIFIER

tial is impressed on the starting anode through a small resistance. When the tube is returned to the vertical position, this circuit is broken and the resulting arc initiates the cathode spot.

Measurements have been made of the current density in the cathode spot, and it is believed to be of the order of 26,000 amp. per sq. in. The heat due to bombardment of the positive ions evaporates a great deal of mercury. From this and other causes a pressure is built up at the cathode spot of the order of two atmospheres although the vessel as a whole has been evacuated as perfectly as possible. The large glass bulb operates as a condenser to condense this jet of evaporated mercury. The high pressure vapor is thus projected into a condenser where the pressure is of the order of 50 microns, that is, 5/100 of a millimeter.

The temperature of the cathode spot has not been definitely established. Some authorities give it as 2000 deg. C., which would be the temperature required to produce the electron stream by heat alone. The actual temperature is probably much lower, although how much lower has not been established. The potential drop required to maintain the cathode spot is approximately 10 v. Approximately half of this 10 v. is consumed in latent heat of ionization of the mercury (work function 4.4 v.) and in the energy of the individual electrons as they escape from the pool. The remaining 5 v. appear as heat at the surface of the mercury pool, about half being used in evaporating mercury, while the other half is conducted away through the liquid mercury in the pool. When the electrons combine with molecules either on the walls of the vessel or at the anodes, the 5 v. represented by their energy is returned also as heat. Such electrons as combine with neutral molecules in the space give up some of their energy in the form of the greenish light so characteristic of the mercury arc rectifier.

About 4-5 amp. current is required to maintain a stable cathode spot. For higher variations of current the area of this spot increases and above 40 amp. more than one spot may exist simultaneously. The spot or

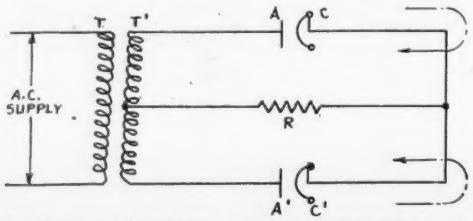


FIG. 3. IDEAL SINGLE-PHASE, FULL-WAVE RECTIFIER CIRCUIT

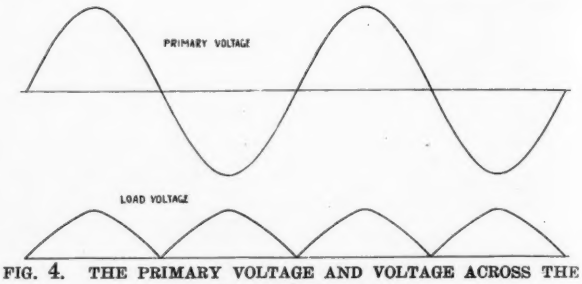


FIG. 4. THE PRIMARY VOLTAGE AND VOLTAGE ACROSS THE RESISTANCE R IN FIG. 3

spots always move very rapidly from place to place, due to the strong blast of mercury vapor and impinging positive ions. In order to make a rectifier operate down to zero current, the auxiliary anodes are provided. These draw a current of approximately 5 amp., so that the cathode spot is maintained in readiness even though the load is disconnected. These auxiliary anodes were not provided in some of the earlier rectifiers, but their provision facilitates many things and may be considered standard in future rectifiers both large and small.

The 10-v. cathode drop does not make up the entire loss. In the high vacuum tube a drop is produced due to the presence of the electrons in the space. In the mercury arc this drop is eliminated by the presence of the positive ions. Whenever a drop tends to exist at any point, the electrons are accelerated until they are able to ionize neutral molecules. The resulting positive ions are of the opposite sign to the electrons so that the net space charge is reduced to approximately zero, but does not disappear completely for some drop is necessary to replace ions lost by recombination and collection by the walls.

Figure 2 shows the form of arc drop curve for a small rectifier. The two lower curves apply to a tube of the same general form as that shown; that is, it has short, straight arms. The lowest curve gives the arc drop characteristic with the bulb cooled only by natural air circulation. To determine whether anode area

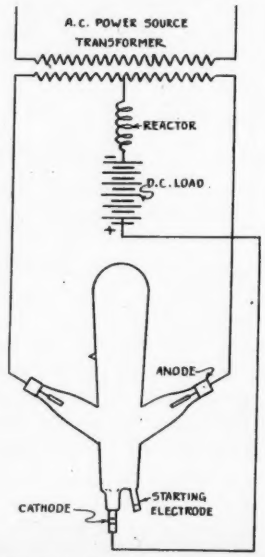


FIG. 5. CIRCUIT SIMILAR TO THAT OF FIG. 2 BUT INCLUDING A BATTERY AND AN INDUCTANCE IN PLACE OF A RESISTANCE

is important, the current has been collected by one anode or by two, and it is observed that the total drop is almost exactly the same in both cases. The characteristic drop reduces to a minimum at 10 amp. and then rises. Below 10 amp., therefore, it has the nature of a negative resistance. In order to operate a mercury rectifier it is, therefore, necessary to include an impedance sufficient to make the average impedance positive; otherwise the tendency would be for the current to rise indefinitely or fall until the arc was extinguished. The rise in the drop beyond 10 amp. is due to excessive vapor pressure produced by heat. The next higher curve, which has its minimum at about 28 amp., was obtained from the same tube merely by cooling the condensing bulb by a 12-in. desk fan. A still greater increase can be maintained by more positive cooling methods such as oil or water. Beyond the minimum points, although the arc drop rises with increase in current, the response to instantaneous variations in current is still that of a negative resistance, so that even though rectifiers are operated beyond the point of minimum drop, two anodes can still not be paralleled without some impedance to force a division of current.

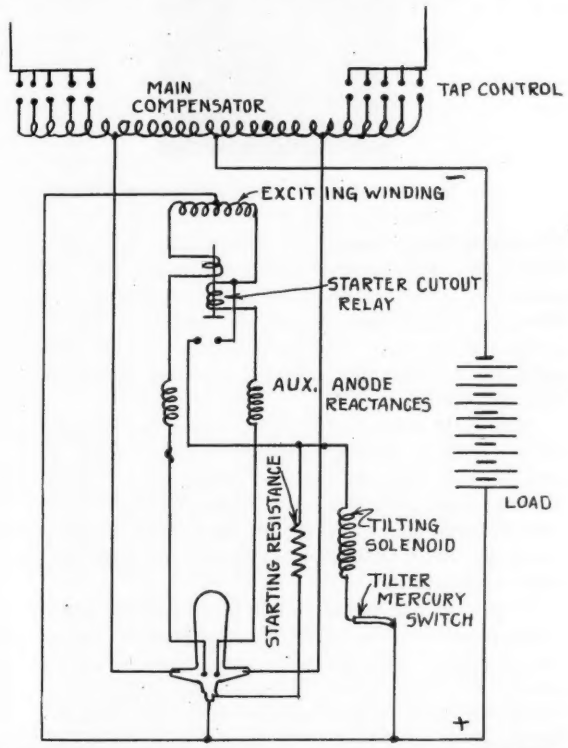


FIG. 7. WIRING DIAGRAM OF A BATTERY-CHARGING RECTIFIER

The two higher curves on this figure are corresponding curves for a tube of the same size but having an elbow in the anode arm. It appears that increasing the length of the path adds a nearly constant voltage drop. Since the drop in the rectifier is a function of current only, the capacity and efficiency are greater the higher the voltage used.

Figure 3 shows the most elementary rectifier circuit. Power is supplied from any alternating current source to transformer primary T. The secondary T^1 is connected at its terminals to anodes a and a^1. In this case high vacuum rectifiers are indicated. The cathodes c and c^1 are connected together and to the midpoint of transformer secondary T^1 through the load R.

Figure 4 shows the primary voltage and voltage across load resistance R. During the half cycle that anode a is positive, electrons flow from c to a; that is, current in the usual sense flows from a to c and returns through R in the direction shown by the arrow. During the other half cycle, a^1 is positive and current flows from a^1 to c^1 and returns through R in the direction shown by the arrow. That is, during both of these half cycles current has flowed in the same direction through R and rectification has been obtained. Since there is no other form of impedance present, the current through R and the voltage drop across R are both sinusoidal in form, but, due to the rectifier action, both half waves are in the same direction. There would be no object in supplying rectified current to a resistance so that these figures are primarily interesting to show the rectifier action in its simplest terms.

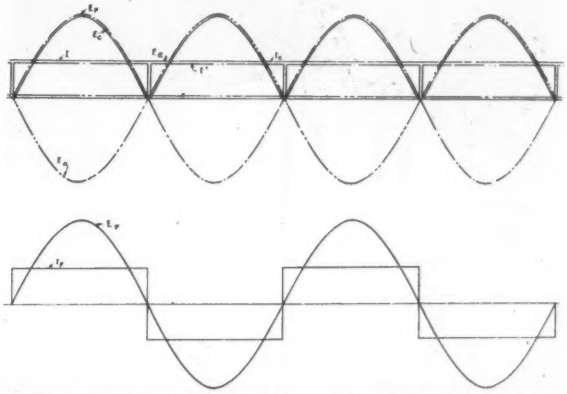


FIG. 6. PRIMARY AND SECONDARY VOLTAGES AND CURRENTS OF RECTIFIER SHOWN IN FIG. 5

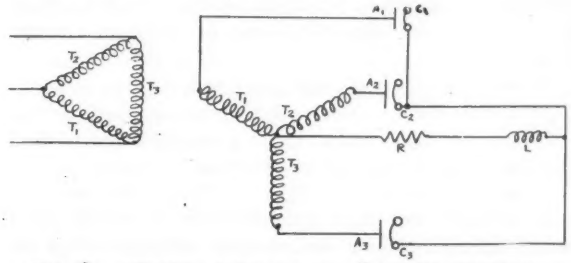


FIG. 8. CIRCUIT DIAGRAM OF A 3-PHASE RECTIFIER

To remove the current pulsations, an inductance may be connected in series with the load. Figure 5 shows a circuit similar to that of Figure 3, but including such an inductance and also including a battery as load in place of the resistance. A mercury rectifier is shown instead of the high vacuum, hot cathode rectifier. The inductance prevents the current from falling to zero, so that the cathode spot is maintained. A mercury rectifier could not be used in the circuit shown in Fig. 3 because it allows the cathode current to fall to zero.

If this smoothing reactor has a large value of inductance, so that the rectified current is held constant, the various waves have the form shown in Fig. 6. The sinusoidal primary voltage is impressed through the

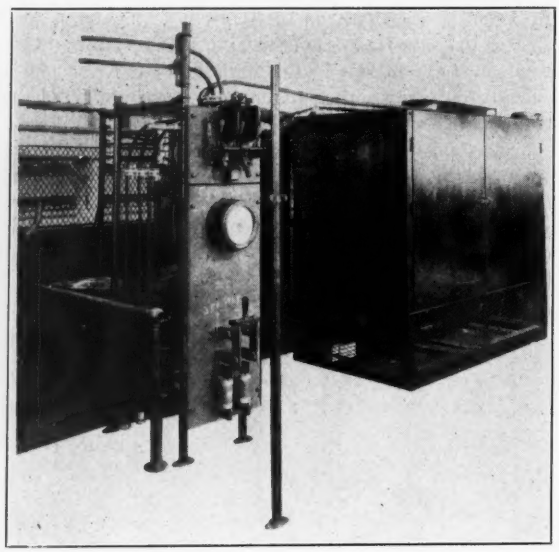


FIG. 9. A 100-KW. MERCURY ARC RECTIFIER

transformer on the two anodes a and a^1. The cathode will assume a potential just enough less than the most positive anode to cause current to flow. The cathode potential is shown as trace e_c. This cathode potential is impressed upon the load circuit consisting of the storage battery and the reactor. Since the reactor maintains the current constant, there can be no variation in voltage across the battery. The entire voltage variation appears, therefore, across the reactor. The steady rectified current is shown at i_R. This current flows from whichever anode is positive for the moment. I and I^1 are, therefore, the respective anode currents. Neglecting transformer exciting currents, the transformer primary current must be of the same shape as the secondary; i_p is, therefore, the form of primary current obtained.

For storage battery charging, it is not necessary to employ a steady direct current. If the mercury rectifier is equipped with auxiliary holding anodes supplied from a separate source, a battery-charging equipment can be arranged as shown in Fig. 7. With this arrangement a small current of approximately 6 amp. is maintained by an auxiliary transformer winding. The battery to be charged is then connected between the midpoint of the main compensator winding and the rectifier cathode. Current will flow to charge the battery only while the anode voltages are higher than the battery counter-electromotive force. Between times the cathode spot is maintained by the auxiliary winding through auxiliary anode reactors which serve both to maintain the current at a steady value and to limit that value. This diagram also shows the arrangements for automatic starting. A relay which is normally closed is connected with its holding coils in the two auxiliary anode leads. When voltage is thrown on the rectifier, current flows through the contacts of this relay to a tilting solenoid and mercury switch which set up a rocking motion in the tube. A circuit is also made to the starting anode through a resistance. As soon as the cathode spot has been formed, the relay opens the circuit to the starting mechanism, and the rectifier is then ready for business. It is kept in an active condition by the auxiliary anodes whether the load is connected or not —a very desirable state where an unknown battery, which may be badly sulphated or even open-circuited, is to be charged.

Figure 8 is a diagram of a 3-phase rectifier. The transformer windings T_1, T_2, T_3 are connected in delta and supplied from a 3-phase alternating current source.

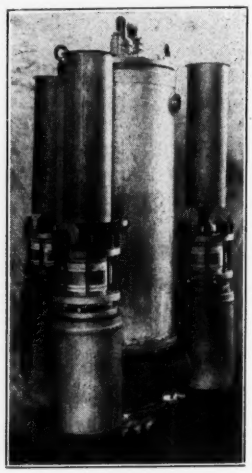


FIG. 10. STEEL-CLAD MERCURY ARC RECTIFIER

The transformer secondary windings t_1, t_2, t_3 are connected Y. The outer ends of the Y are connected to anodes a_1, a_2, a_3. The cathodes are connected together through an inductance L and the load R to the Y point of the transformer. Hot cathode rectifiers are indicated although no change would be involved in inserting a mercury rectifier.

Figure 9 shows a 100-kw. rectifier now supplying a shop circuit in the Schenectady Works. This rectifier employs two of the 250-amp. glass tubes. From the earliest days, attempts were made to make rectifiers of iron in large sizes. Figure 10 shows one of these early rectifiers which was modeled closely in form after the glass rectifier.

One objection to the iron type of rectifier set usually constructed is that some leakage always occurs with bolted joints, although the amount may be exceedingly small. For this reason, it is necessary to have a vacuum pump attached to the rectifier, although it need not be operated at all times. Attempts have been made to avoid the need for a vacuum pump by the use of seals fused directly to the metal parts. One unit of this type has no clamped joints between metal and insulation, and, by the use of well-fitted metal-to-metal joints, the danger of leakage is greatly reduced. It is possible to go still further and make rectifiers in which the sealing is complete. A small rectifier of this kind showed no indications of impaired vacuum 3 mo. after being evacuated and sealed.

MERELY WISHING for a better job isn't going to get it for you. Of course, wishing is better than no desire at all; but the chaps who turn wishing into concentrated thought and work are the ones who will bring home the bacon.

Effect of Opening the Field of Alternators

An Analysis of the Action Which Takes Place When the Field of an Alternator Running in Parallel with Others Is Opened. By Leander W. Matsch

WHEN THE FIELD switch of an alternator is opened while it is in parallel with others any one of the following three conditions may result.

1. The unit may drop its entire load.
2. It may drop about 50 per cent or more of its load.
3. It may drop about 10 per cent of its rated full load.

In all cases the system pressure would be materially reduced although the amount by which it would be lowered would depend on the number of generators on the system and the loads on the different units. Since there is a tendency for alternators operating in parallel to maintain equal field strengths provided they are the same designs and capacity and carry equal loads (in generators of unlike design this condition is somewhat modified), a lowering of the field current in one causes it to generate a cross-current which is leading or magnetizing with respect to the generator whose field had been weakened and lagging or demagnetizing with respect to the others. There will then be a lowering of the bus pressure unless the field current in one or more of the generators is increased. This cross-current varies inversely with the synchronous impedance of the generators.

It is essential in order properly to analyze the action of a generator whose field had been opened to consider also the action of the prime mover and to regard the generator with its prime mover as a unit. This paper is intended to deal chiefly with the action of turbo-alternators.

Opening the Field of an Alternator Carrying Full Load

Let us take for example an alternator with a field entirely cylindrical in shape and an armature of high synchronous impedance carrying nearly full load, its prime mover being a steam turbine with a sluggish governor. As soon as the field is opened, discharge resistances are closed in parallel with the field, thus closing the field circuit and leaving the exciter disconnected. There will be a leading cross-current flowing through the armature, but due to the cylindrical shape of the field the flux set up by the armature can not link sufficiently with the poles to hold the rotor in synchronism. At the instant the field is opened and its circuit closed by the discharge resistances, the current in the armature will build up due to the cross-current; this rise in cross-current causes a current to flow in the closed field winding and eddy currents in the iron circuit of the field on account of transformer action. This condition causes considerable surging.

At this point it may be proper to consider the action of the turbine. The tendency for a prime mover when receiving power (as steam in the case of a steam turbine) is to drive the alternator to which it is connected ahead of the others operating in parallel and since the field had been deprived of its d.c. exciting current, there is no field flux to interlink with the armature flux, which is the flux of a rotating field, the machine is actually driven ahead of the others. This condition follows the surging mentioned in the preceding paragraph immediately and the generator is functioning asynchronously, i.e., as an induction generator, the closed field winding and the iron circuit acting similarly to the rotor of an induction motor or induction generator. There will then be a considerable drop in load but before the load can drop to zero the unit has increased its speed. Since the action of the governor is sluggish some of the load will be retained, the amount of load so retained increasing with the speed of the unit. As the unit increases its speed the tendency of the generator is to take on more load, while that of the turbine is to drop load due to throttling action by the governor.

Since the governor action is sluggish the speed at which the generator tendencies would be in equilibrium with the turbine tendencies would be above tripping speed of the turbine and the throttle would trip, causing the steam to be shut off and allowing the speed of the unit to decrease until it is sufficiently below synchronous speed to operate as an induction motor. The impedance of the armature was too high to permit enough cross current to flow, thus insufficient flux was set up by the armature circuit to allow the machine to function as an induction generator at a speed below tripping speed. These events would take place in a very short time, depending, of course, on the inertia of the moving parts of that unit. The power factor would be leading as long as the machine is operating as a generator, and lagging when operating as a motor. In each case the power factor would be exceedingly low.

Action of a Unit Operating Under Light Load

Let us now consider the action of this same unit under a light load when its field switch is opened. The action would be the same as described in the preceding discussion except that owing to the fact that the machine is operating under a light load the governor is set so that less steam is admitted for over speeds than at full load setting; therefore the generator loading tendencies would be neutralized by the turbine tendencies at a lower speed. This speed may be below the tripping speed of the turbine. If this is the case then there will be a considerable drop in load due to the increase in speed and the machine will operate as an induction generator with its power factor leading.

From the preceding analyses it may be understood that my contention is that the unit would always drop its entire load when the field switch is opened while the machine is carrying full load. This, however, is not true when an alternator having an armature with a low impedance is considered. The cross current in this case would be great enough to set up sufficient flux to permit the generator to function asynchronously below tripping speed of the turbine; the action here would be the same as in the case of an alternator with high impedance having its field switch opened while operating under a light load. Since most governors on turbo-alternators are set to trip at over speeds from 7 to 12 per cent, considerable throttling action would set in before those overspeeds are reached, hence making the two preceding conditions possible.

The preceding arguments are applicable only to alternators having cylindrical fields, although they would hold true also in the case of alternators having fields with slightly defined polar projections and high synchronous impedance to such an extent that it would be too great to allow the machine to remain in synchronism because the flux set up by the armature is of too low a value to interlink with the small pole pieces. If the synchronous impedance, however, is low, there will be enough cross current flowing through the armature to set up sufficient flux to interlink with the poles and hold them in synchronism, although the poles may be a fraction of a pole ahead of "in phase" position. There would be a drop in load due to the increase in wattless (leading) current which may be four or five times the full load current, the drop in load then would be four or five times full load losses or about 10 per cent full load.

Alternators with salient poles would always remain in synchronism.

From the preceding discussion, it may be concluded that the factors determining the behavior of an alternator when its field switch is opened are:

1. The shape of the field.
2. The action of the governor of the prime mover.
3. The synchronous impedance of the alternator.

Some Small Turbines of Unique Design

TURBINE GENERATOR SETS RECENTLY DEVELOPED HAVE TURBINE ROTOR OVERHUNG ON PINION SHAFT OF REDUCTION GEAR. BY J. A. MACMURCHY*

DURING THE PAST ten years a large number of turbine-driven generator sets in ratings of 50 kw. to 500 kw., for both a.c. and d.c. service, have been built, having turbines operating at from 6000 to 7200 r.p.m.

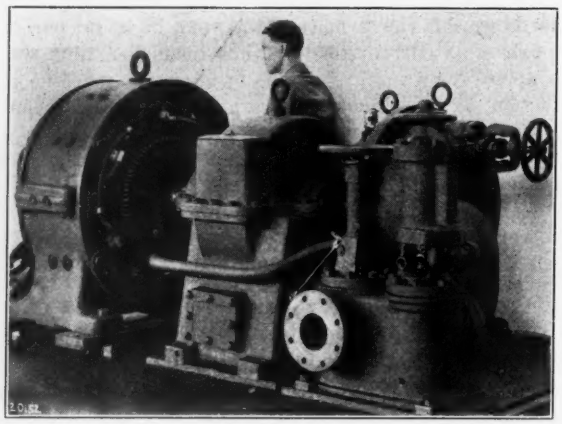


FIG. 1. TURBINE GENERATOR SET OF NEW DESIGN FOR 50 TO 500-KW., SHOWING GOVERNOR VALVE, CASING CONSTRUCTION AND METHOD OF CONNECTING GENERATOR

and connected through reduction gears to 900 and 1200-r.p.m. generators. The operating record of these generator sets has been extraordinarily good and has proved that the building of a turbine to operate at a high rotative speed most adaptable for the design and employing a generator which in turn is designed to operate at its best speed, the two connected by means of a reduction gear, produces a most desirable unit from the standpoint of reliability and efficiency.

Despite such an excellent operating record, the Westinghouse Electric & Manufacturing Co. has redesigned this type of generator, the development of a successful oil governor having made it possible to simplify the construction and effect improvements which could not previously be attained. The new units have all the advantages of direct-connected generator sets, at the same time, retaining the advantages gained by the use of reduction gears.

It is rather misleading to refer to these units as geared turbines because the popular impression of a geared generator set is that of a unit consisting of a turbine having its own two bearings coupled to a gear having four bearings, which in turn is coupled to a generator having two more bearings; that is, a set having eight bearings and two flexible couplings. The new Westinghouse generator sets have only five bearings and no flexible coupling. The only coupling in the unit is the solid flanged coupling between the gear and generator and it will be noted that this is on the slow speed shaft.

These new turbines are of the single disc, re-entry type, which, during many years, has been found to be so suitable for noncondensing operation in small capacities.

TURBINE ROTOR IS OVERHUNG ON PINION SHAFT

One of the distinctive features of the new design is that the turbine rotor is overhung on an extension of the pinion shaft. By means of this construction the difficulty of maintaining the high speed turbine rotor in accurate alinement with the pinion is entirely avoided and, of course, no turbine bearings are required and only one spindle gland. The fact that the space occupied is considerably reduced is not of great consequence. The important point is that a machine so built is a better operating machine, is easier to install and easier to overhaul.

Another distinctive feature of these machines is that the speed is controlled by an oil governor. By this is meant a governor in which the centrifugal force acting on a column of oil in an impeller replaces the conventional fly-balls. This in itself is an old idea but was not successfully used until about 1909; since that time hundreds of turbines of capacities up to 6000 kw. have been equipped with oil governors with uniformly satisfactory results.

The oil governor consists of a simple centrifugal pump impeller mounted on the end of the pinion shaft. Oil is supplied to the suction side of the impeller from the main lubricating system and the pressure is raised to that required for the governor control, the oil from the impeller being carried through a pipe to a piston the motion of which is resisted by a spring. This piston is connected to the governor valve. Since the pressure delivered by a centrifugal pump varies as the square

*Manager, Small Turbine Engineering Dept., Westinghouse Electric & Mfg. Co.

of the speed, the pressure on the piston compresses the spring as the speed increases, moving the valve in the direction of the closed position; similarly, as the speed is reduced, the oil pressure drops and the governor valve moves to a more open position.

Some of the advantages of the oil governor are:

(a) It may be mounted directly on the turbine shaft without intervening gears. Its efficacy is not in the least impaired by operation at high speed.

(b) The force of the governor is transmitted to the piston, which opens and closes the valve, without any intervening linkage.

(c) It is an extremely simple device and, although the parts are comparatively small, they are substantial and there are no knife edges or revolving clutches to wear out.

(d) There is practically no friction in the governor itself so that it is extremely sensitive and at the same time stable.

Lubricating Oil Is Supplied from Governor System

Still another unusual feature of these turbines is the means provided for circulating the lubricating oil. This

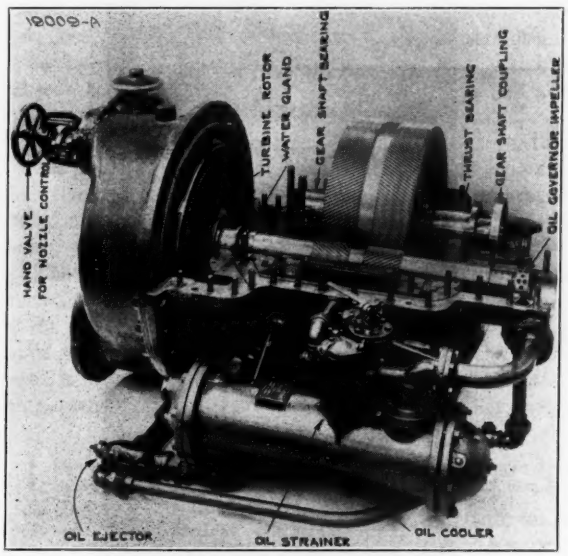


FIG. 2. REMOVAL OF CASING REVEALS OVERHUNG ROTOR, BEARING ARRANGEMENT, OIL GOVERNOR IMPELLER AND GLANDS

is done by taking a portion of the oil from the governor impeller and passing it through an ejector mounted at about the level of the bottom of the gear case, which serves as a reservoir for the lubricating oil. This high-pressure oil passing through the ejector picks up a large quantity of oil at a lower pressure and this is circulated first through the oil strainer, then through the cooler, then to the bearings and gear teeth.

This avoids the necessity for an oil pump and for the gears by means of which oil pumps are usually driven. A turbine might, of course, be provided with ring-oiled bearings and the need for oil pump or gears be thus avoided, but the system here described provides unfailing flood lubrication, designed to eliminate wear. The importance of an absolutely reliable lubricating system is generally appreciated.

It will be noted that the ejector which circulates the oil for lubrication also furnishes oil under slight pressure to the governor impeller which is not self priming, thus the oil governor and the ejection system of lubrication are very necessary to each other and, when combined, they constitute a speed-regulating device and a system of lubrication which are simple, reliable, and lessen maintenance expense.

As there are no turbine bearings and only one spindle gland, the turbine cylinder becomes a simple affair and is carried overhung from the gear case, part of it being cast integral with the gear case. The end of the cylinder which carries the high-pressure steam passage

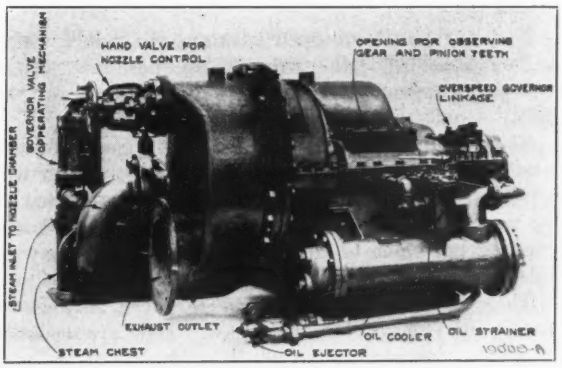


FIG. 3. ANOTHER VIEW OF TURBINE SHOWING STEAM CHEST DETAILS

with the nozzles and nozzle control valve is made a separate piece so that it can readily be made of cast steel in case the steam temperature is considered too high for cast iron. There is quite an advantage in having the turbine carried on the gear case in that there is only one piece to line up with the generator. The cylinder, being supported by a circular connection to the gear case, may expand due to steam temperature without affecting the alinement. It should also be noted that the only shafts to be coupled are those of the gear and generator, both of which are slow speed parts and by the omission of the inboard generator bearing the alinement problem becomes quite simple so that a solid flange coupling may be used.

The steam chest carries not only the governor valve and its control but also includes a quick-closing throttle valve under control of the emergency overspeed device. The latter may be used as a stop valve, as it opens and closes just like any ordinary globe valve. The steam chest is arranged to be bolted substantially to the foundation so that there is no danger of the pushing or pulling of the steam pipe causing trouble.

Safety Provisions

It is seldom that a steam turbine overspeeds to the point at which some part of the rotating element fails due to centrifugal force but, no matter how good the speed-regulating device may be or how reliable the emergency overspeed device may be, such an accident is possible. An accident of this kind is likely to cause serious damage to property and may result in loss of life. These new turbines not only are equipped with an extremely reliable governor that is almost impossible

to misadjust and with the best possible emergency overspeed governor but if, due to any combination of circumstances, they do overspeed, no part of the rotating element can come out of the case, therefore there is no danger of injury to the operators. The manufacturers do not promise, in the event of such a serious accident, that the turbine will not be greatly injured but they do promise that nobody will be hurt. With a view to demonstrating that the means proposed for preventing injury as the result of overspeeding was efficacious, three of these turbines were deliberately overspeeded by disconnecting the governor and the emergency overspeed governor, with steam turned on, yet there was very little injury to the machines except that it was necessary to reblade the rotors.

Each turbine is equipped with an oil strainer which can be cleaned while the turbine is in operation. There is also an external oil cooler of ample size and of the quality usually furnished with large turbines.

No bedplates are furnished with these generator sets as nothing is gained by the use thereof. Soleplates will be provided to go under the various elements so that in case any part of the machine has to be removed, the grouping need not be disturbed and the part may be replaced without realining.

These units are built in sizes to cover a range of capacity of from 50 kw. to 500 kw. They are designed for steam pressures up to 400 lb. and total steam temperatures up to 750 deg. F.

The back pressure against which small noncondensing turbines are required to operate usually varies from atmospheric to 10 lb. gage but occasionally the back pressure is greater than this. This line of turbines has been designed so that they will operate satisfactorily with back pressures up to 25 lb. They can also be operated condensing and, when so operated, the steam consumption is greatly reduced.

Although intended primarily as a drive for electric generators, these turbines can of course also be used as a drive for any apparatus within the range of their capacity.

An unusual feature of these machines is that, while the turbine is in operation, the speed can be changed from about one-third speed to full speed without stopping the turbine. This may be of great value for certain industries as, for instance, in paper mills.

Republic Boiler Meter Panel

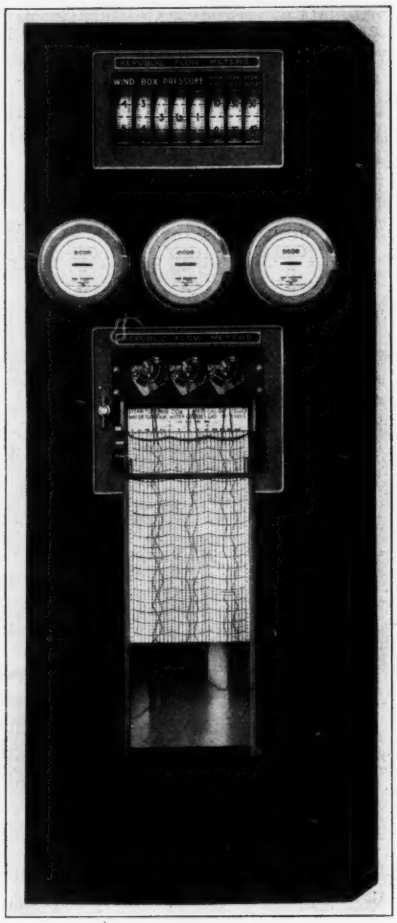
RECORDS OF STEAM AND WATER FLOW AND OF GAS AND WATER TEMPERATURES ARE CORRELATED WITH DRAFT PRESSURE INDICATIONS. BY F. A. FURLONG

NEED for accurate and continuous information concerning the vital phases and results of boiler operation is generally accepted and the flow meter, the CO_2 recorder, the flue gas temperature recorder are now established facts in the operation of modern plants.

It is realized, however, that for proper interpretation of one record, many of the others must be considered, so that instrument grouping is desirable, although it is quite common to find a CO_2 recorder in one location, a flow meter in another and a temperature recorder in a third.

Centralized grouping of the instruments, permitting observation of all records simultaneously, makes the actual boiler operation easier and is particularly convenient when the attempt is made to correlate the various graphic records at the end of a day's operation, but a group of individual instruments frequently requires more space than is available where many instruments are used.

Logical solution of this problem lies, of course, in recording all the essential facts on one chart. It is obvious that little is gained by such combination if the accuracy or visibility of any of the records is seriously



THIS PANEL COMBINES INDICATIONS AND RECORDS OF FLOW, CO_2, TEMPERATURES AND DRAFT PRESSURES

impaired, as a maze of intertwining lines, even though they be of different colors, is not only a hindrance to intelligent operation, but a decided barrier to the proper analysis of the records. Also, where a number of movements are to be combined in one case, it is almost essential that the various movements be similar, at least in space requirements, or the resultant instrument will be cumbersome and unsymmetrical.

In designing the Republic Boiler Meter Panel, preference was given to the strip type of chart as the medium most suitable for a multiple record instrument, as affording uniform time values at all points of the scale, and permitting ready comparison of records. A wide chart is used, divided into three zones, in effect,

three distinct charts perfectly synchronized and having the advantage of continuous juxtaposition for purposes of operation and analysis.

More than two records combined on any one chart endanger the value of the record through interweaving, and, wherever possible, the two records are selected so that interweaving is either minimized or else utilized as an operating aid. Thus the temperatures of the flue gas entering and leaving the economizer are usually plotted in the same zone since they can never intermingle; flow of water to the boiler and flow of steam from the boiler are plotted in the same zone since the interweaving of these records is, in itself, a sign of good operation, which dictates that the rate of water supply should be regulated to meet the variations in the steam demand.

In the operation of any boiler, two points are of paramount importance—rate of heat absorption, or the work done by the boiler and the rate of heat loss. The steam flow graph is, of course, a positive record of the heat absorption of the boiler since each pound of steam at a given pressure and superheat represents a definite number of heat units. Heat loss in a boiler is really a combination of various losses, such as radiation, stack loss, loss in ash pit, loss due to hydrogen, and others. It so happens that the major loss and that which is subject to widest variation is the stack loss. Other losses, in any given plant, will seldom vary sufficiently from day to day to reflect a change of more than 2 or 3 per cent in the total. Therefore, it may be said that the stack loss is a true and satisfactory operating index of the total boiler losses and, therefore, of the boiler efficiency.

The one most positive method of determining the stack loss is through the CO_2 content and temperature of the waste gases. For any given fuel, the loss at any given temperature and per cent of CO_2 in the waste gases is definite. Therefore, both the CO_2 and the stack temperature are charted on the Republic boiler meter in such a way that the two records may be observed simultaneously and in conjunction with the steam flow.

Besides the three records of steam flow, CO_2 and flue gas temperature, which are so vital to economical operation, auxiliary records are highly desirable. This meter lends itself to such auxiliary records so that the complete story of the boiler operation may be written on one chart. The choice of auxiliary records will be determined by the character of the steam generating equipment. Thus, where economizers are used, it is desirable to graph the flue gas temperature when entering as well as when leaving the economizer. Water temperature leaving the economizer is also important, since the efficiency of the economizer unit is reflected by the increase in water temperature at a given rate of flow. Where air preheaters are employed, a knowledge of the temperature of the inlet and outlet air is necessary in working out the boiler room heat balance.

Besides the graphic records outlined above, certain conditions of operation are best shown by indicating instruments which are all embodied in one case known as the Republic multiple draft indicator. This and the integrating instruments necessary for calculation and logging of results are mounted, with the Republic graphic boiler meter on one unit boiler meter panel, which thus affords a complete survey of the boiler operation.

The panel employs the same electrical indicating, recording and integrating units which have been used in Republic instruments heretofore. Thus, in the boiler meter, provision is made for six electric recording elements essentially the same as have been used in the Republic flow meter recorders, recording on one 12-in. chart. The chart is driven by an electric clock at a normal rate of travel of 1 in. per hour. A feature of this instrument is that the entire day's record is visible at all times and opportunity for one shift to compare its results with another has always been a strong stimulus to better operation.

Use of the P-I Diagram for CO_2 Refrigeration

LACK OF ACCURATE KNOWLEDGE REGARDING BEHAVIOR OF CO_2 THROUGHOUT CYCLE HAS LED MANY ENGINEERS TO AVOID IT. BY H. J. MACINTIRE*

UNTIL quite recently it seemed as if carbonic refrigeration had little future because of the reputed inefficiency of the cycle, its large leakage of gas, its high pressure and its larger power requirements than are necessary with ammonia. More recently conditions have been improved and certain cooling work has been practically restricted to the use of carbon dioxide. For example, few hotels or theatres use ammonia compressors.

It appears highly probable that considerable of the difficulty on the part of the engineer with the carbon dioxide refrigerating cycle is due to a lack of appreciation of the behavior of the refrigerant throughout the cycle. The term "critical temperature" appears to offer considerable difficuly to their understanding and the belief is common that no refrigeration can be obtained if the temperature of the refrigerant leaving the condenser is 88 deg. F. (the critical temperature) or higher. That such is not the case is evident from the fact that carbonic compressors are used successfully on board steam ships crossing the equator and, to some extent, in stationary installations in the tropics. However, one can see this best on a diagram and particularly on the P-I diagram for carbon dioxide.

*Associate Professor, Refrigeration. University of Illinois.

THE P-I DIAGRAM

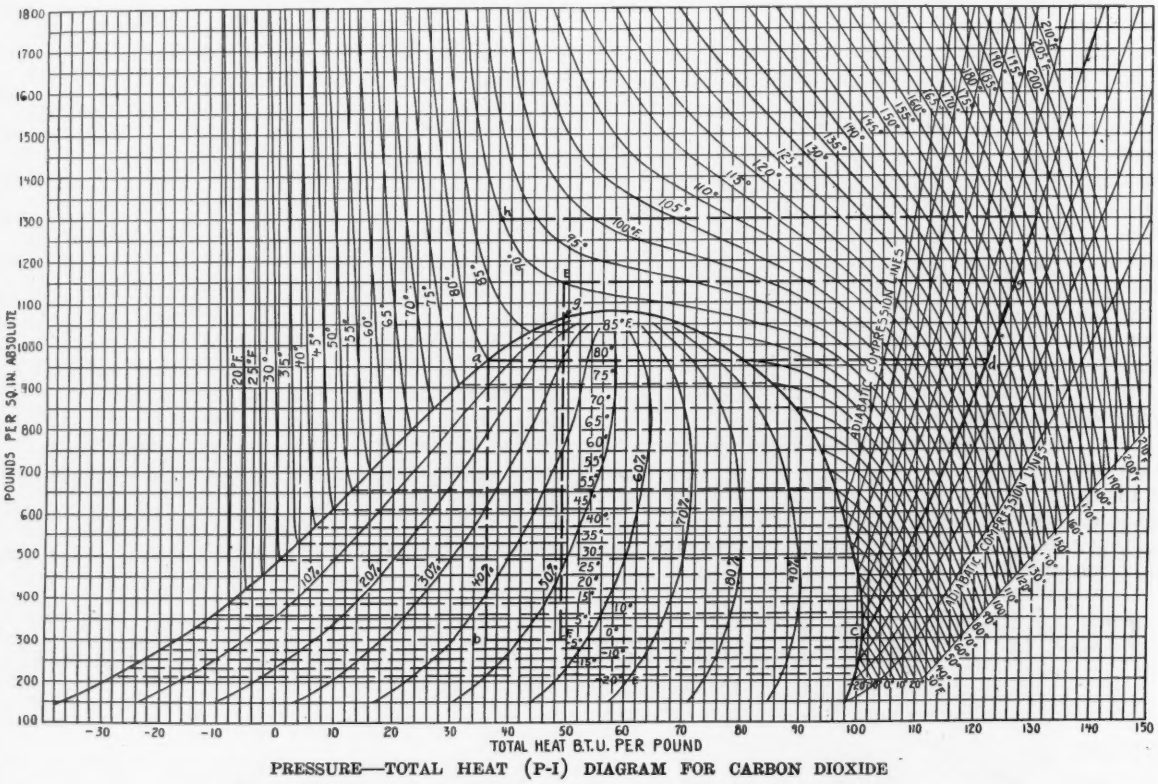
The P-I diagram, similar to the chart for ammonia in circular No. 142 of the Bureau of Standards, has the absolute pressure as ordinates and values of the thermal potential (I) as abscissa. The thermal potential is carelessly called the total heat and it is that quantity that is constant during the flow through the expansion valve. The heavy line on the left-hand side is the so-called liquid line and the heavy line on the right-hand side is the dry, saturated vapor line. Between these two lines is the condition of saturation, or conditions representing a mixture of both liquid and vapor. To the right of the dry saturated line is the region of superheat, where there is no particular temperature corresponding to a particular pressure as exists in the saturated region. The

point where the liquid line and the saturated vapor appear to meet is called the critical temperature condition, above which the vapor cannot become a liquid no matter how heavy the pressure may be. The critical temperature is not clearly defined but it is very nearly 88 deg. F.

The Refrigerating Cycle

The refrigerating cycle using 70 deg. F. water is represented by the cycle abcd. Starting with liquid carbon dioxide at the expansion valve at a the flow through the expansion valve is represented by the constant I process ab, and during the process a certain amount (44 per cent) of the liquid at a is vaporized in order to cool the remainder of the liquid to 0 deg. F. as indicated by the point b. The process bc is the action of boiling the refrigerant in the evaporating coils and it corresponds to a net refrigerating effect of the difference in the values of I at b and c or it is equal to 101 — 36 = 65 B.t.u. per lb. CO_2. The gas at c is now understood to pass to the compressor and it is compressed along the so-called adiabatic (curved) line cd to the point d, which represents a pressure of 965 lb. and a temperature of 142 deg. F. The work of compression, per lb. of carbon dioxide, is given by the difference in the value of I in the two points c and d or it is 122 — 101 = 21 B.t.u. Finally the process da is the action of the condenser which first removes the superheat and then liquefies the carbon dioxide. The amount of heat removed by the condenser cooling water is 122 — 36 = 86 B.t.u. per 1 lb. carbon dioxide.

Should the temperature of the cooling water be 80 deg. F. or more so that the refrigerating cycle becomes efcg then the gas will not be condensed, as the point e is above the critical temperature. The condition e is not that of a liquid but it has some of the characteristics of a liquid. It is a very dense gas with the density nearly that of liquid carbon dioxide. It is in unstable equilibrium and it reacts chemically with an "indicator" with some of the characteristics of a liquid and with some of a gas. The action of the expansion valve is shown by the line ef which indicates clearly that during the pressure drop, first all the dense gas becomes a liquid at g and then as the temperature decreases, a certain amount of the liquid is evaporated in order that the remainder will be cooled so that at f only 51 per cent will remain liquid and the remainder will be gas. The net refrigerating effect will be decreased to 52 B.t.u. whereas the work of compression becomes 26 and the heat removed by the condenser 78 B.t.u. per lb. CO_2.



PRESSURE—TOTAL HEAT (P-I) DIAGRAM FOR CARBON DIOXIDE

Based on experiments by Jenkins and others. Computed by H. J. Macintire.

The net result of having high condensing temperatures is to get less refrigeration per lb. of the refrigerant and more work will be required of the compressor. These are inherent losses and very little has been done in decreasing them; however, there is no time when some refrigeration is not possible by the use of carbon dioxide. One might ask as to what pressure will exist in the condenser if the temperature is 88 deg. F. or above. This is a variable quantity dependent on conditions. If a non-condensible gas is pumped into an after-cooler (the condenser of the refrigerating cycle) the pressure exerted depends on the weight and the temperature of the gas and the volume of the after-cooler. The marine engineer will frequently overcharge his plant with gas in order to increase the "condenser" pressure for he knows that by so doing he can reach a point h instead of e (with the same temperature of the gas at the expansion

valve) and thereby increase the refrigerating effect slightly from 52 to 63 B.t.u.

The carbonic refrigerating cycle therefore is one which is essentially the same as any of the other refrigerants. The fact that the gas will not condense if the temperature of the CO_2 leaving the condenser is 88 deg. F. or higher is not essential. The efficiency may be slightly less than those of other common refrigerants, but CO_2 has many compensating advantages and these will be taken up in a later article.

Water Hammer in Steam Heating Systems

By R. A. Cultra

DURING the heating season many engineers are deluged with complaints about annoying pipe lines and radiators. In many large buildings there are several long pipe lines of large diameter and often few drain pipes or traps on the line between the boiler and the end of the pipe. This often is the cause of water hammer.

In one case a 4-in. angle valve was used to control a horizontal heating line of 100 ft. along the wall of the power plant, going through the wall at this angle valve. There was no drain on this pipe line depending on a few branch lines to take care of the condensate. Then, also, the angle valve was closed only when necessary to make pipe repairs in the other buildings. The main stop near the boilers had beeen closed for the season and to prevent leakage the angle valve also had been closed while repairs were made and not again opened until orders came to turn on the steam for the heating season. As there were no drains on the line, the slight leakage at the boiler valve had allowed this pipe to fill partly with water and no doubt the operator opened it without the customary method of warming up and the volume of water set in motion came against this valve disc like a battering ram, knocking off the bonnet, breaking the flange bolts on one side and a piece out of the bonnet flange on the other side. This accident caused a delay of several hours until a new valve could be put on.

In another case water hammer caused the side to be blown out of a 4-in. Y pipe fitting. This accident came near causing injury to an employe who just started down the stairs when the Y on the ceiling at the bottom burst. The operator had previously been warned of the risk of explosion from water hammer, as this pipe was 200 ft. long and had only one short drop bend as it entered the building where it branched at the Y, one line supplying steam to a hydraulic elevator pump and the other to the heating system. There was only a ¾-in. drain in the line near the Y and no doubt the trap could not relieve the volume of water in the time he had allowed.

Steam Mains Should Have Adequate Drainage

All steam mains should have numerous drain pipes to relieve them of condensate so if one steam trap becomes inoperative the others will relieve the line and prevent accident. A steam pipe which has had steam shut off all night will be entirely cold in the morning and a small volume of steam turned on will condense to water rapidly, being followed by more as each foot of the pipe length is slowly heated. By allowing only a small amount of steam to pass through the valve and thereby keep the pressure in the pipe at only a few pounds until the pipe is warm, less condensate will accumulate and, opening the valve a little more, the pressure will build up gradually so that with no water present there will be no water hammer and no broken fittings.

What causes water hammer? In the above mentioned cases, it is caused by insufficient drains on long steam lines to drain out the condensate as fast as it accumulates. The longer and straighter the pipe, the greater will be the force at the end, since with the pressure of steam back of it the water accumulates speed as it travels. Usually there is a certain amount of air in addition to the water in the pipe and, when the steam is turned on too quickly, it drives the water against this air to the other end of the pipe, compresing it and emitting a thud or snap while back of the water the steam is partially condensed. This condensate adds to the water in the pipe and at the same instant the air which has been compressed expands again, forcing the water back against the steam. The steam coming in faster and in greater volume forces the water to the other end of the line again with greater velocity striking a heavier blow each time until the fitting breaks or the pipe splits to relieve it.

In short pipe lines, having many elbows, however, the short lengths do not allow the water sufficient length of travel for increasing its velocity to the point where sufficient force is acquired to break the fittings, especially if they are extra heavy and care is used in warming up the pipe. With long pipe radiators on ceilings or side walls of factories and even the small cast-iron ones in offices, it is quite different. The long pipe radiators often will be found sagged in the center, sometimes to a depth of 2 in., thus allowing the pipes to fill with water at that point if the steam is shut off and the valve leaks. Also, when the valve is opened, it will fill in this low portion until there is sufficient pressure in the pipe to force it out.

Water Hammer Most Frequent in Gravity Systems

Water hammer occurs most frequently in gravity return heating systems where the condensate returns to a receiver tank below the level of the water in the tank. When the steam is shut off at the main valve and the radiators cool, a partial vocuum is formed within. This causes the water to rise from the receiver tank up through the return pipes into the radiators of the lower floors to a height which such vacuum can lift the water, until the tank is empty and air enters through the vent pipe to destroy the vacuum. It is well to see that the stop valve is closed ahead of the float-operated supply valve for make-up water to such receivers as it would allow more water to be drawn into the radiators.

In office buildings where the steam has been shut off for some time and the valve opened suddenly, there is considerable water hammer until the water is forced out. Since usually the radiators are of cast iron, it is well to have check valves on the return pipe near the receiver when it is necessary to connect return pipes below the water line.

In changing over an old high pressure heating system to a back pressure exhaust steam system which could be operated on gravity or vacuum return lines, it was necessary to put up new supply and return lines. To prevent dirt getting into the headers of some of the radiators until they could be connected to the risers, the fittings were plugged with paper or wood. When the job was complete, one of these long coil radiators developed water hammer which could not be accounted for since a vacuum system was used. There were, of course, radiator return traps on each radiator and why the trap did not work was a question.

The steam was shut off and the trap taken out, only to find a wad of paper lodged within. The fitter then recalled the fact that when he made the steam connection to the header, one of the paper plugs was missing but he thought it had been pulled out. Probably some thoughtless person poked it into the header.

When return traps become plugged with scale, they often cause the radiator to fill with water from the steam condensing therein and water hammer indicates the return trap is choked up.

Wetted Ash Needs Careful Handling

By Eugene Hahn

TEN YEARS of experience in ash-handling problems are behind me, hence, I noticed with great interest the query in the November 1 issue of Power Plant Engineering.

How can wetting of ashes be avoided in the average boiler plant? If charged hot into a mechanical conveyor its maintenance will be large. If wetted, in which case the action of the heat may be avoided and even the abrasion somewhat reduced, increased action of corrosion due to wet ashes has to be assumed, in addition to the tendency for packing and arching in the tank, with likelihood of freezing in cold weather.

Skip hoists and industrial cars, because of mechanical simplicity, are damaged by wet ashes to a less degree, but the tanks into which they discharge are subject to the same difficulties as before.

Pneumatic or pipe-line conveyors are little affected by the abrasive and corrosive action of either dry or wet ashes, as they have no moving parts—only the ashes move—and are usually cast in thicknesses of ¾ in. to 1 in. in hard or white iron. If steam consumption is moderate, elbows properly designed and protected with durable liners and objectionable noise and dust are avoided, they are well suited for conveying ash.

While the ashes can be charged red hot into such conveyors, they will become moist to a degree through contact with the jet or jets of steam in case of steam-jet or induction-type conveyors, which means that they are wet when entering the tank. In case of vacuum conveyors, which operate by a partial vacuum or suction throughout, no contact is made between the steam jet and the ash. With this type, however, the tank has to be provided and maintained air tight and consumption of steam is larger than with a steam-jet conveyor.

Since it appears that, with most conveyors and equipment, ashes will enter the storage tank in a more or less wet state, the following points should be observed to prevent damage to the tank and to insure free discharge from it.

Cast iron will resist both abrasion and corrosion better than steel plate. When constructed in sections, which are readily accessible for possible replacement, the maintenance of cast iron tanks is insignificant; also they can be erected and dismantled readily.

When discharging through the bottom, the horizontal dimensions of the tank should be as uniform as possible, since the conical pile forming within the tank will compress against the sides which are nearest to the center. For this reason, a cylindrical tank is the best, while a square tank is the worst. An octagonal tank approaches the shape of a cylinder closely enough and has the advantage that its component plates are flat which simplifies its steel structure.

The tank should have a hopper bottom at the proper angle, which should be conical or near conical. An octagonal pyramid is more uniform than a rectangular pyramid. Flat bottom tanks will, no doubt, form a cone of ash around the gate opening but the friction between ash and ash is much greater than between ash and metal.

Even in a cylindrical tank with a conical hopper bottom, moist ash is likely to pack and arch. By passing agitators horizontally through the tank, this condition can be helped, provided these agitators are convenient to operate from the outside.

Freezing occurs in the lower strata of the ash within the tank, as the moisture is bound to trickle down and the narrowest body near the gate is most exposed to the cold air. Live steam injected at this location is bound to thaw out the frozen ash, which through the rotation of the agitators can then be discharged. Naturally the injection of steam should be made simultaneously all around the gate, with the slots or ports protected from possible clogging.

In case of a side-discharge tank, uniformity of the horizontal dimensions is of less importance so long as there is a slope of proper angle toward the gate or gates but, for free discharge of the entire contents, the full front of the tank should be "gated." As this is constructively difficult and often otherwise objectionable, cutting off of the front corners in the tank has been found effective, as it reduces the frontage of the tank that is to be "gated," while it still induces the ash to flow toward the outlet or outlets. Agitators and thawing-out steam chamber should be applied to suit the design for side discharge.

Whether the ash is charged into the tank through a pipeline conveyor, bucket elevator or skip hoist, it should not be dropped for the full height. An obstruction or splash member should be placed at the top of the tank, which will tend, not only to distribute the ash to better advantage within the tank, but also to break its impact, thereby preventing a too compact formation above the gate or gates.

The Michigan Northern Power Co. has resumed operations at its power plant at Sault Ste. Marie, which has been closed since last August when a leak was discovered in the quicksand under the station. Repairs and improvements have been carried out and it is proposed to render continuous service for an indefinite time.

Method of Obtaining Water Content of Boiler

KNOWLEDGE OF the quantity of water contained in a boiler at its normal water level is often useful, particularly with reference to calculations for water treatment, water required for filling, etc. For finding the water content of a 6,000 sq. ft. heating surface, type "M" Stirling boiler the writer used the following method. While the method is not as accurate as actually weighing the water pumped into the boiler to fill it, it is close enough for practical purposes.

The number and lengths of the various tubes that are filled with water when the boiler is filled to normal water level are:

Tube No.	Number of Such Tubes	Length of Each in Ft.
1	20	18.25
2	20	17.25
3	20	16.50
4	20	16.00
5	20	15.375
6	20	18.50
7	20	17.75
8	20	17.50
9	20	17.125
10	20	17.25
11	20	19.50
12	20	19.50
13	20	19.75
14	20	19.75
15	20	20.75
16	20	20.75
19	21	3.75
20	21	4.25
21	21	4.75

The total added length of filled tubes is 6288 ft. The internal diameter of the tubes was 3¼ in., representing an area of 8.3 sq. in., or 0.057 sq. ft. The total volume of the tubes is then $6288 \times 0.057 = 358.4$ cu. ft.

Content of mud drum: The area of the cross-section of the 48 in. diam. mud drum was 12.57 sq. ft., this multiplied by the length, 14.75 ft., gives 185.5 cu. ft., the water content.

Contents of steam drums: The boiler had three 42-in. diam. steam drums with the center drum slightly raised above the two end drums. The normal water level was at the middle of the end drums. The area of cross-section of the 42-in. diam. drum is 9.62 sq. ft., which, for the two end drums each one-half full, $2 \times 4.81 \times 14.75$ ft. long $= 140.2$ cu. ft. content. The middle drum was raised so that three-eighths of the tank was full of water at normal level, hence: $\frac{3}{8} \times 9.62$ sq. ft. $\times 14.75$ ft. $= 53.0$ cu. ft.

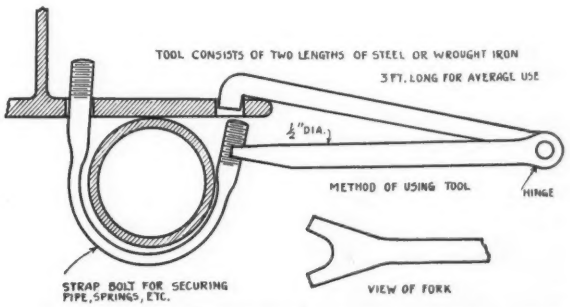
The total water content of the boiler then is: $358.4 + 185.5 + 140.2 + 53.0 = 737.1$ cu. ft., which, at 7.48 gal. per cu. ft., would give 5518 gal. as the water capacity.

To obtain the pounds of water contained, the cu. ft. content is multiplied by the density of water at the temperature of operation, in lb. per cu. ft.

Baltimore, Md. J. A. BARNARD.

Special Tool for Handling Heavy Strap Bolts

FREQUENTLY THERE IS occasion to replace strap bolts used to secure pipe, braces, truck springs and for other purposes. At such a time the tool illustrated herewith


TOOL CONSISTS OF TWO LENGTHS OF STEEL OR WROUGHT IRON
3 FT. LONG FOR AVERAGE USE
½" DIA.
METHOD OF USING TOOL
HINGE
STRAP BOLT FOR SECURING PIPE, SPRINGS, ETC.
VIEW OF FORK

CONSTRUCTION OF TOOL FOR HANDLING HEAVY STRAP BOLTS

is possibly one of the most expeditious to use. It is a simple device to construct.

Two hinged wrought iron bars, with a single hinge rivet, form the tool. One end of one of the bars is bent to provide a secure grip, while the corresponding end of the other bar, is forked to engage the U-shaped strap bolt.

In use the bent end is inserted in the bolt hole, and the tool is used to pry or spring the strap bolt in alinement with the hole.

Washington, D. C. G. A. LUERS.

Knocks and Friction

MANY TIMES I have been asked to help locate the cause of a pound in a steam engine which often lies indirectly in the conditions and tightness of the packing around the piston rod. Although this cause is quite common it appears to me that many engine room workers never give it a thought when a thump suddenly develops. They get all "het up" and start tightening or loosening all bearings, glands, etc., indiscriminately, except the one gland which, when a liberal use of cylinder oil and loosening its packing would give temporary re-

lief until such a time that proper determination of the real or direct reason for the pound may be made.

At one plant I demonstrated that even with new packing in the box a very severe pound could be produced by simply overtightening the packing. A packing that has been used even for a short time around an overheated rod will have become charred and can never be made steam tight unless it is over-tightened. Such defective packings have been put to re-use after they have been soaked in cylinder oil for a few days, but they never function properly as they are required to be overtightened in order to make them steam tight.

Later at one plant the direct cause for the pound which was due to lost motion was located at the wrist pin and the cylinder. After a general inspection of the bearings the cylinder head was removed disclosing the fact that the piston head was held up from the bottom of the cylinder for part of the stroke when the piston was moving in the direction of the outer head. Then, as the weight of the head and piston rod become too great, they dropped and at the same time lifted the crosshead, so that the knock was produced in two places at the same time. With loose packing the piston was free to drop gradually and the knock was not produced. We all know that a knock or pound in a steam engine means lost motion somewhere.

Hard packing in a loose box may produce a very loud thump. When it is impossible for any reason to shut down an engine for any length of time in order to locate the real source of trouble when a pound persists, it is strongly advised that the piston rod box be refilled with new packing and carefully tightened just enough to have it steam tight. In nine cases out of ten this procedure will reduce the severity of the pound for the time.

Often the feed pumps in a steam plant are extremely noisy because the rod packing and the piston packing are so tight that the whole pump is jerked at every stroke.

Excessive friction is a trouble maker and a money waster around machinery and it often is a noise maker also.

Toronto, Canada JAMES E. NOBLE.

Fuel Value of Wood

THE FOLLOWING in regard to the fuel value of wood is given in paper No. 98, of a series of Technical Notes issued by the Forest Products Laboratory, U. S. Forest Service, Madison, Wisconsin:

Two pounds of dry wood of any nonresinous species has about as much heating value as a pound of good coal. Speaking in tons and cords, a ton of coal may be taken as the approximate equivalent in heating value of 1 cord of wood, 1½ cords of medium-weight wood, or 2 cords of light wood.

Based upon 80 cu. ft. of wood with a moisture content of 15 to 20 per cent, the number of cords of seasoned wood of various kinds needed to furnish in combustion approximately the same amount of heat as would be obtained in the combustion of 1 t. of coal, is shown as follows:

1 cord approximating 1 t.: Ash; beech; birch; cherry; elm; hickory; locust; maple, hard; oak; and pine, long-leafed.

1½ cord approximating 1 t.: Fir, douglas; gum, red; hemlock, western; maple, soft; pine, short-leafed; and sycamore.

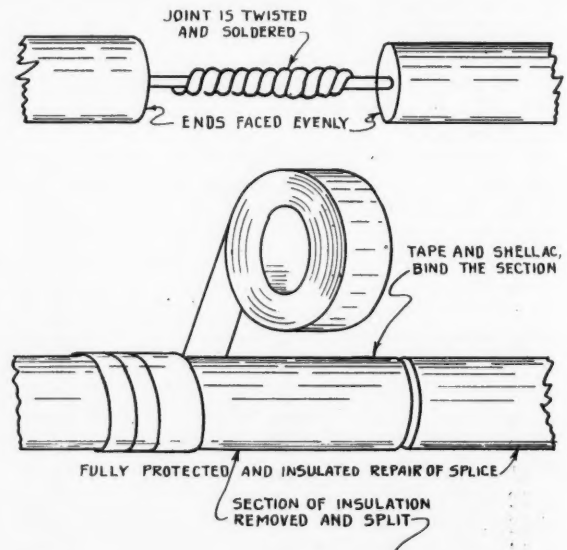
2 cords approximating 1 t.: Basswood; catalpa; cedar; cypress; pine, white; poplar; redwood; and spruce.

Newark, N. J. W. F. SCHAPHORST.

Replacing Insulation on a Spliced Wire

INASMUCH AS ordinary electric tape will loosen in the presence of oil or harden and fall off under conditions of heat and vibration, a means was devised for insulating the joint by means of a section of the same rubber insulating material used to cover the wire.

Sketch herewith shows in detail the procedure in replacing the insulation. This procedure consists in first making up the splice in the usual manner, squaring the edges and twisting and soldering the wire. A length of insulation equivalent to the splice, cut from the end of a piece of the wire, is then slit and pushed


JOINT IS TWISTED AND SOLDERED
ENDS FACED EVENLY
TAPE AND SHELLAC, BIND THE SECTION
FULLY PROTECTED AND INSULATED REPAIR OF SPLICE
SECTION OF INSULATION REMOVED AND SPLIT

SHOWING HOW TO MAKE A THOROUGHLY INSULATED JOINT THAT WILL BE ALMOST AS SECURE AS UNBROKEN ELECTRIC WIRE

over the joint. It is advisable to use shellac and bind this with tape to hold it securely.

The insulating quality of a joint prepared as above is about the same as that of the uncut wire.

Washington, D. C. LEWIS GEORGE.

Weighing a Light Article on a Platform Scale

BY WEIGHING on both ends of a platform scale it is possible to find the weight of a letter, in order to ascertain the amount of postage necessary. The method is based upon leverage and simple proportion or what is called moments.

One pound on the beam balances 100, 200, or 1000 lb. on the platform depending upon the ratios between the platform and beam. Weigh yourself and remain on the platform, then place the light article on the beam or suspend it from the beam and take the weight again. Suppose, for example, on a scale with a 1 to 100 ratio we had 160 lb. at first weighing and 150 at second when light article was on beam, then 160 — 150 = 10. Now, pointing off two places, we have 0.10 lb. To convert this to ounces multiply by 16.

When weights are not used on the beam, determine the ratio by placing a small known weight on the beam and find the proportionately larger weight balanced on the platform. By this means the number of feet of wire in a reel may be determined by cutting off a piece 12 in. long and weighing it as indicated above and then weighing the whole reel on the platform.

Pittsfield, Mass. T. H. REARDON.

Some Peculiar Situations in Small Plants

TECHNICAL INFORMATION such as furnished by power plant magazines is needed to even a greater extent by the small plant than by the larger power station because the former has no specialized men in its organization upon whom to call for technical advice; hence one frequently meets some peculiar situations in plants of small size.

One small plant having two vertical 25-hp. fire-tube boilers used steam for process work consisting mostly of steam-jacketed kettles and other boiling equipment. The boilers were located in a depressed room adjoining the building so that they were about 10 ft. below the level of the steam equipment. The pressure of steam carried was 30 lb. gage. All the steam used was condensed and returned to the boilers through traps, one trap being applied for each group. Three indirectly heated vats had their coils drain into one trap; while three kettles drained into another. The other auxiliary equipment drained into two other traps, all of which were the tilt type. These traps all dumped into a raised receiver tank located above the boilers. One return tilt trap dropped the condensate directly from the receiver tank into the boilers, no valve being placed between the trap and the boilers. At the same time, both boilers had automatic float feed water regulators, fed from a city line, that maintained about 50 lb. pressure. The receiver was at practically atmospheric pressure.

The drain traps discharged the condensate from the equipment into the receiver tank, but considerable trouble was experienced in maintaining a constant water level in the boilers. Both boilers were continually filling up, necessitating constant blowing down, with its attendant heat and other losses.

As it appeared to me, the trouble was caused by the following conditions: The feed water regulators maintained the level of the water in the boilers from the city line. This level was carried very high. At the same time, the trap would discharge all the water from the receiver tank into one or both boilers regardless of water level. The piping from the trap was more direct to one boiler than the other, so that the former would get most of the condensate, and of course, more quickly fill up. With water coming in from the city lines during low periods while the receiver and trap were filling, the boilers were receiving much more water than they were discharging as steam.

One day the operating engineer asked my advice. In view of the 10-ft. difference in level between the boilers and the equipment, on a boiler pressure of 30 lb., I suggested bypassing all traps, and running the return lines directly into the boilers, through check valves to prevent backing up of the boiler water in case of trouble with the return line. This would give a closed system of direct return, with a five-pound head on the condensate above the boiler pressure. On my next visit to the plant, I found that my suggestions had been tried. Every trap was bypassed and the return lines run directly to the boiler feed line behind the regulator, so that city water would not be used unless the condensate was insufficient.

Results were better than expected. The operation became very smooth and no water was held back in the system by receiver or trap. The water level was maintained without difficulty.

Dayton, Ohio. C. W. STEVENS.

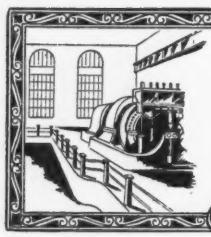
Extension for Inaccessible Drain Cocks

NECESSARY REARRANGEMENT of piping often leaves a drain cock in a somewhat inaccessible place. Hot and tight at times, such cocks are hard to open. The photograph shows how an extension can be quickly made of

AUTOMOBILE VALVE MAKES OPERATION OF INACCESSIBLE COCK EASY AND CONVENIENT

an old automobile valve by splitting the end of it and drilling a hole through the handle portion of the cock plug. The extension may be permanently riveted onto the cock handle or held with a cotter pin. The valve disc furnishes a good handle and the device, as a whole, makes the opening and closing of an inaccessible cock an easy and convenient operation.

Missouri Valley, Ia. FRANK W. BENTLEY, JR.



QUESTIONS AND ANSWERS

Effect of Low Power Factor on Generators

On a three-phase power system there are three turbo-generators operating in parallel with two hydro-electric plants. When all plants are operating, is it possible for a generator to drop off the system due to a low lagging or leading power factor? Could a generator drop out of step with a 30 per cent leading power factor? A discussion of this subject by other readers will be appreciated. F. O.

Can Cement Dust Be Removed from Insulators?

In one of the substations on the system with which I am connected, we are having trouble due to deposits of cement dust on our high voltage insulators. This substation is located near a cement plant and the fine dust and moisture which collects on the insulators forms a hard cement coating. We should like to know whether there is any practical way of removing this coating or preventing its formation.

Jackson, Michigan. A. W. R.

Coal Consumption and Steam Distribution

Please let me know the answers to the following questions:

1. If the average indicated horsepower is 400, and 26 t. of coal are burned in 24 hr., how much coal is used per horsepower per hour?

2. What will be the consumption of coal per horsepower per hour if a total of 6 t. of coal is used in 24 hr., the engine indicating 150 hp.?

3. Tell how to set the valves on a plain slide valve engine.

4. Why is steam cut off in the cylinder of an engine before the piston completes its stroke?

5. Is the same lead given the valve of a high-speed engine as to a low-speed engine? Explain in full.

6. What is the difference in the regulation of speed when an automatic shaft governor is used or when a throttling governor is employed? Describe both fully.

L. J. W.

A. Assuming 2000 lb. to the ton, we would have $2000 \times 26 = 52{,}000$ lb. burned per 24 hr., or $52{,}000 \div 24 = 2167$ lb. per hr. Then, $2167 \div 400 = 5+$ = the number of lb. per hp. per hr.

2. Again assuming 2000 lb. per ton, $2000 \times 6 = 12{,}000$ lb. consumed per 24 hr., or $12{,}000 \div 24 = 500$ lb. per hr. Then, $500 \div 150 = 3\text{-}1/3$ lb. per hp. per hr.

3. The subject of valve setting is too large for these columns. We would refer you to one of the excellent texts on this subject, such as Slide Valves by Halsey, published by D. Van Nostrand Co. of New York City; Valves and Valve Gears—2 volumes—by Furman, published by John Wiley & Sons, New York; Valve Setting by Collins, published by McGraw-Hill Book Co. of New York. All of these books may be consulted in the Engineering Societies Library at 29 W. 39th St., New York City.

4. Steam under pressure has the property of expansion and hence does work while expanding. If steam is not cut off in a cylinder, the steam would be exhausted at the pressure of admission which is high, hence the work is performed inefficiently. If the steam is cut off, the steam continues to do work while it expands although the pressure drops and the rate of doing work is reduced, hence the work obtained under these conditions per lb. of steam is much greater than when it is not expanded.

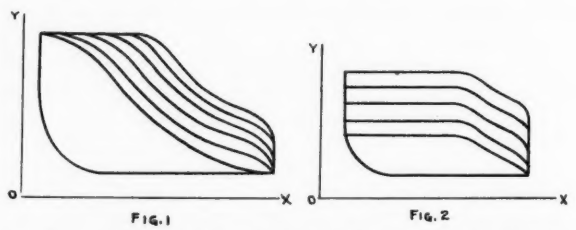


FIG. 1. INDICATOR CARD SHOWING EFFECT OF AUTOMATIC GOVERNOR WHEN LOAD ON ENGINE IS VARIED

FIG. 2. INDICATOR CARD SHOWING EFFECT OF THROTTLING GOVERNOR WHEN LOAD ON ENGINE IS VARIED

5. High-speed engines are usually given much more lead than the ordinary slow-speed engines. Lead is given in order to better facilitate the entrance of steam to the cylinder, the faster the engine runs the shorter time is the steam port open, hence the advantage of opening this port sooner to provide a longer time of opening.

6. Governing through an automatic shaft governor regulates the point of cutoff in the cylinder as shown in Fig. 1. Governing by throttling regulates the initial pressure in the cylinder as shown in Fig. 2. In the former case, other events in the steam distribution would also be changed as the cutoff is changed but these changes are not illustrated in order to avoid confusion.

In throttling governing, centrifugal action causes the weights on a flyball governor to fly out when the speed is increased. This action is communicated through rods and levers to a valve in the steam line, closing it more or less according to the speed.

Shaft governors are of two types, centrifugal and inertia. In the former, weights attached to the flywheel fly out as the speed increases, moving the eccentric across the shaft, reducing the throw of the valve as the

speed increases, making the events earlier and hence cutting off the steam earlier. The inertia type consists of an arm with unbalanced weights at its ends. This arm swings about a pin in the flywheel hub and hence it does not move concentric with the flywheel. In operation, as the speed increases the centrifugal force of the unbalanced weights causes them to move outward, thus moving an eccentric or a valve rod pin across the shaft, decreasing the throw of the valve as before. If, however, a sudden change of load should occur, the weights will tend, for a moment, to continue at the same speed at which they were traveling and thus run ahead or lag behind. The result of this action, which is due to the inertia of the weights, is to change the position of the eccentric or valve rod pin in its relation to the center of the shaft thus reducing or increasing the throw of the valve as the case may be. In such a governor the inertia of the cross bar and weights materially supplement the centrifugal force and increase the sensitiveness of governing.

The shaft governor permits of more economical governing because it cuts down the amount of steam taken by the engine while permitting full expansion from practically the same high pressure. There is a slight decrease in initial pressure when an automatic cutoff engine is speeded up very fast due to slight wire drawing because of the short time the steam port is open.

Codes and Leads

WILL YOU PLEASE tell me where I can obtain a copy of the "United States Marine Boiler Code" and the boiler code for the City of Chicago?

How much lead should be given to the valve of a vertical moderately high-speed steam engine having a 6-in. diam. cylinder and an 8-in. stroke? A. M. C.

A. A copy of the United States Marine Boiler Code may be obtained from The Steamboat Inspection Service, Federal Building, Chicago, Ill.

The boiler code for the City of Chicago is out of print and it is not known when a new issue will be published, but the A. S. M. E. Boiler Code is followed. Copies of this latter code may be obtained from The American Society of Mechanical Engineers, 29 W. 39th St., New York City, for 60 cents. Members may obtain it for 55 cents.

For a steam engine, the amount of lead varies from less than $\frac{1}{16}$ in. on small engines and with low speeds up to over $\frac{1}{8}$ in. on large engines and with high speeds. For your case, therefore, $\frac{1}{16}$ in. would be about right.

Comment on the Hump on the Card

COMMENTING ON the indicator diagram shown on page 1346 of the December 15 issue, I believe the valve on the crank end opens at the proper instant but does not continue opening up fast enough to keep up the pressure behind the piston. In other words, the speed of the engine causes the piston to run away from the steam. On the head end the valve should open sooner and cut off sooner; this would give a better expansion line and lower release pressure.

It may be possible also that the port area is not sufficient for the engine at its present speed. The engine speed may have been increased at some time for manufacturing purposes. If it were slowed down slightly the hump would disappear from crank end. The valve on the head end should be reset so as to give quicker opening and cutoff.

Rockford, Ill. THOS. L. FOLEY.

Effect of Dam on Flow

WHAT EFFECT will a dam have on flow of a river 400 ft. wide, 10 ft. deep and moving at about 5 mi. per hr., the dam being 12 ft. high, backing up water 7 mi.? I can understand that the space at A would have its flowage influenced by the dam, but what about that part of the river lying upstream from A? Why and how much, if at all, would this latter area be affected? T. L. F.

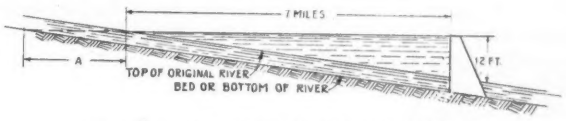


FIG. 1. RELATION OF DAM AND RIVER

A. Flow of water in a river is controlled entirely by the friction of flow, the water at each point in the river finding its own level. At the place where the river flow enters the reservoir created by the dam there may be a slight increase of head represented at BC in Fig. 2 due to the sudden reaction to flow caused by the large quiescent body of water. The flow of the river, in this section, therefore, would be slightly affected to an

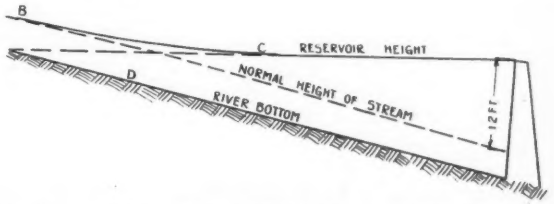


FIG. 2. SHOWING HOW RESISTANCE TO FLOW, CAUSED BY ENTRAPPED BODY OF WATER, SLIGHTLY RAISES HEAD OF RIVER

amount equal to the increased head but sections of the river above A in Fig. 1 would not be affected at all, unless obstructions to flow are encountered, in which case the action would be similar to that at the entrance to the reservoir at the dam, as described above.

Selection of Fuses and Relays

PLEASE LET me know the basis for selection of motor fuses and relays? C. N. B.

A. In selecting a fuse for motors it is desirable to use the smallest possible size that will carry the load. Usually the running fuses should be approximately 115 to 125 per cent of the amperage as shown on the name-plate of the motor. If the same fuse is used for starting as for running it will be necessary to use one about twice as large as the name-plate amperage. Time limit fuses are usually selected with approximately the same amperage as that shown on the motor with which they are used.

The same consideration should be used in the setting of overload relays. They should be set as low as possible and still carry the load. They should never be set greater than 110 to 125 per cent of the name-plate amperage of the motor. The ability to make close adjustment of relays is one of their advantages over fuses.

EDITORIAL COMMENT

Government and Gold Bricks

As a source of trouble the Colorado River holds high place among the streams of the country. Threat of floods is ever present and has presented gigantic engineering problems. Wasted power possibilities worry thrifty-minded engineers but development is complicated by water rights of several states which do not agree on the method. Irrigation rights are also a source of disagreement.

Now it comes forward as an excuse for proposing that the Federal government enter the power plant field on a huge scale in competition with private enterprises and under conditions which make even physical success at least problematical. In the Swing-Johnson bill (HR 9826), which comes from Congressman Swing of the Imperial Valley district, provision is to be made for building a dam 600 ft. high at Boulder Canyon, 300 mi. from Los Angeles; for construction of a canal to prevent the present diversion of waters of the river into Mexico; for construction of a 1,000,000-hp. power plant; for advance to the Boulder dam fund of $125,000,000 to cover construction costs and interest during the construction period, bond issue being authorized to provide the funds. Estimated costs are, for the dam, $41,500,000; for the canal, $31,000,000; for the power plant, $31,500,000, and it is proposed to repay the money advanced by selling water for irrigation, by selling power at the plant or by selling water to private applicants who will build their own power plants. It is understood that the Secretary of the Interior does not favor the third option.

Income is estimated as $1,500,000 from sale of water for irrigation and domestic supply; $10,800,000 from sale of 3.6 billion kw-hr. at 0.3 cent a kw-hr. Annual expense is figured as $700,000 for the dam and power plant; $500,000 for the canal; $5,000,000 interest for 4 per cent on $125,000,000, leaving $6,100,000 annually towards liquidating the bond issue.

Adventuring in government ownership and operation of utilities has not produced a comforting record. Railroad operation, purely a war measure, is looked back upon as a billion dollar mistake. Muscle Shoals, also a war enterprise, but only a tenth as large as the Colorado River proposal, is a subject for contention with no solution probable in the near future. No sudden access of knowledge or experience has occurred which indicates greater success in future undertakings.

As to physical and financial uncertainties, the proposed dam would be nearly twice the height of any now in existence and five annual floods in a narrow canyon must be dealt with during the period of construction. Even if construction is possible, conservative engineers estimate the cost of the entire enterprise as nearer $200,000,000 than $125,000,000. Flood control is desirable, but can be accomplished by a dam at Topac to cost only $14,000,000.

On the income side, cost of transmission power is $10 a year per 100 mi., so to get to Los Angeles, the nearest market, would cost $30 a horsepower-year. This, plus the 3 mills cost at the plant per kw-hr., would bring the cost of current in Los Angeles to $50 a horsepower-year, and steam generation there now costs $40. Also there would be 1,000,000 hp. for sale, the present total electric load of southern California being 750,000 hp. Who is to use the additional power? Either present generating plants would go out of service or power use would have to double, neither being probable. A struggle would then develop between private and government plants for the load, with municipally owned distributing systems in Los Angeles and surrounding territory likely to swing over to the government power supply.

Why should the Federal government enter the power field? Present facilities are adequate for customers' needs and the Federal Water-Power Act protects development of power sites in the public interest. Why not go into orange or olive or prune or wheat growing? Investment would be less and success more probable.

Apparently the bill is another effort to get the government committed to a big attempt at ownership and operation of utilities, the taxpayer being the prospective goat in case the adventure does not live up to promises. We need to get it firmly in mind that the proper function of government is to protect the lives, health and opportunities of citizens, not to do for them things which they can and should do for themselves or to undertake costly adventures for the satisfaction of faddists. Then we need to insist that our representatives in government confine themselves to carrying out that proper function and leave off chasing isms and gold bricks.

Public Utility Power Production in the United States

It is interesting to note, from a recent report of the Department of the Interior that in certain sections of the country wood is becoming of increased importance as a fuel in public utility plants.

Central stations, electric railway and other plants generating electricity for public use are included in the report, their total production for the year totaling some 65,870 million kw.-hr. Of this total, 250,000 kw.-hr. are generated from wood, an item of 0.264 per cent of the total, not an imposing figure in itself, but representing 9.4 per cent of the total power produced from fuel in the ten leading wood burning states.

Eliminating California from this list raises the percentage of wood produced power in the remaining nine to 22.3. As is to be expected, the northwest leads in the utilization of this product, over 99 per cent of the power

produced from fuel in Oregon and Idaho being credited to wood.

As the wood burned is waste product, the practice is an excellent example of by-product utilization, a field not generally associated with the public utilities. Although the practice is of necessity confined to timbered regions, the country as a whole is well represented with the northwestern states followed in their order of importance by the southeastern, Great Lakes, southwestern, northeastern and middle western states.

With such widespread application we may expect some degree of standardization in this field with wood classified according to physical and chemical characteristics as coal is now. If analyzed thoroughly, furnace, stoker, refractory and grate problems for certain classes are undoubtedly similar regardless of the geographical location, and although little may be expected from industrial plants the importance of economy and freer interchange of communication of public utility plants offers possibilities along this line.

As a matter of interest, there are a number of other points brought out in the report, namely that New York, for the last few years, has led consistently in the total production of power ranging between 15 and 16 per cent of the total produced in the entire country. About 34 per cent of the total produced in all the states is generated by water power with New York and California alternating between first and second places, averaging between them about 40 per cent of that generated from this source.

Pennsylvania, New York, Illinois and Ohio rank equal in production from fuels, making approximately 50 per cent of the total produced from this source. Records for this division show a steady gain in efficiency during the past seven years with coal consumption, gas and oil figured as equivalent coal, decreasing from 3.2 to 2.1 lb. per kw.-hr.

When compared to our best central stations producing a kilowatt-hour on less than a pound of coal, 2.1 may not appear to advantage, but when one considers the small size and low load factor of many of these stations it assumes increased importance although still far from what might be considered entirely satisfactory.

With the exception of 1921, which showed a decrease of about 6 per cent in production, every year has meant a steady yearly increase in the production of power, practically a doubling of the industry in seven years, certainly a remarkable indication of the growing importance of power in the economic and industrial life of the country.

Use the Opportunities at Your Door

When the standardization of industrial engineering nomenclature was started by the Society of Industrial Engineers, among those whose valuable assistance added much to the success of the undertaking was Miss Christine Haller of the Detroit Public Library, who has since become Chief of the Business and Commerce Division; in fact, the centralization in Detroit of the nomenclature committee was partly due to the excellent facilities offered by the Detroit library and also to an appreciation of the knowledge, ability and responsive assistance of Miss Haller.

In the city of Brooklyn, Edward F. Stevens, librarian of the Pratt Free Library, developed a technical reference library that has been copied by libraries all over the country, whose representatives received their inspiration as well as technique from Mr. Stevens.

In Chicago, the celebrated John Crerar Reference Library is located where information of every technical nature from all parts of the world is gathered and catalogued for quick reference.

This recital of the services available in the libraries of the country could be extended to every industrial city in the country and might even include the libraries of many manufacturing and engineering concerns that are interested in keeping their men informed on every phase of their industry. Many engineers are thoroughly familiar with the services which librarians are rendering but those who are not, will do well to get acquainted with their home town library. Permit the librarians to help you find the things that interest you; they are always glad to help you.

New discoveries are combinations of old ideas and those combinations are most likely to occur to the mind, not when one is handling material things, but when he is brooding over the thoughts of other men and rethinking them in terms of his own experience. The library will help prevent you from repeating errors of other men. It will reveal to you ideas that, when developed upon the foundations of your own practical experiences will lead to important contributions to your field of work.

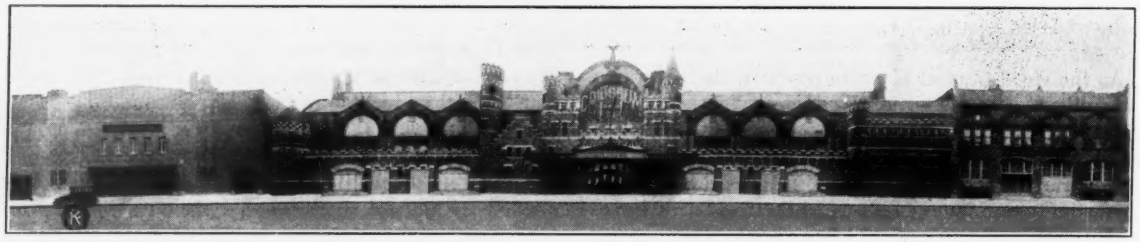
Frequent use of a public library need not imply neglect of establishment of one's own private library, in fact, the opposite effect usually results. Some of us prefer to have our own books because we are in the habit of reading with a pencil in our hand and because we can find things in a book we have marked up quicker than in a new volume of the same text. Some of us believe that if a book is worth reading through it is worth having in our own library. The public library affords an opportunity for not only selecting books for our own library but for consulting many books on specific subjects. Likewise, nothing will take the place of a person's own technical magazine. No book is ever nearly so timely as a live magazine on a given subject.

Neglect not your own library, however small it may be, nor neglect regular reading of the technical magazine that covers your field, but be not slow to take full advantage of the public library at your door; you will find "acres of diamonds" there.

Because the coyote detests artificial light, finding it bad for both his eyes and his business, he is slinking away from regions traversed by transcontinental air mail routes, according to a news report. Swinging beams of electric light marking the routes proved too much for him, and caused him to seek sections where there is more comfort, even if food is harder to get.

Three-million-candlepower revolving searchlights are placed at 25-mile intervals, and smaller flashes between, which arrangement renders two valuable services, one of them entirely unexpected, for the lights that guide flyers at night also save the sheep of the ranges for miles around by driving away the coyotes.

City authorities and factory owners have also found the value of light in driving away the undesirable prowler. Many farmers who have provided their yards with general lighting for convenience have discovered a protection from marauders and nocturnal animals.



Midwest Engineers Will Journey to Chicago

EXHIBIT OF MOST MODERN PLANT EQUIPMENT AND FOUR-DAY CONFERENCE ON INDUSTRIAL POWER USES WILL BE MAGNET FEBRUARY 15 TO 19

HOUSED in the Coliseum, which is conveniently located on Wabash Avenue near 15th Street and containing over 300 exhibits, the Midwest Power Show and Midwest Power Conference will bring to Chicago on those dates the pick of the power plant engineers of the central west. Last year's record of 1200 registrations at the Conference and many thousand visitors to the Show is an indication of the interest taken and of the larger attendance to be expected this year.

The Coliseum is reached by Wabash Avenue or State Street surface lines by Elevated trains to 12th Street (Roosevelt Road) and by South Side bus lines. Transfers can be made to these lines from West Side and North Side lines easily.

Displays and demonstrations of latest designs and improvements, engineers in attendance who have specialized on power plant problems and economy and conference addresses by foremost authorities on plant design and operation will offer an unlimited opportunity for study and investigation which will well repay any power plant man for effort and time required to attend.

Exhibits will be open from 12 noon to 10:30 p.m. on Tuesday, Feb. 15, to Saturday, Feb. 19, for the inspection of visitors.

POWER CONFERENCE

Meetings of the Midwest Power Conference have been arranged by a committee representing local organizations of the American Institute of Electrical Engineers, the American Institute of Mining Engineers, the American Society of Mechanical Engineers, the National Electric Light Association and the National Safety Council, with William S. Monroe, president of Sargent & Lundy as chairman.

At the first meeting on Tuesday, Feb. 15, at 2:30 p.m., Mr. Monroe will deliver an opening address, reviewing progress in the power plant field during the past year and W. W. Freeman, president of the Union Gas & Electric Co. of Cincinnati will speak on the effect of wide distribution and interchangeability of power on industry.

The second meeting on Wednesday morning at 10 o'clock will have papers by Wilfred Sykes of the Inland Steel Co., on the use of power in steel mills, by Joseph J. Merrill of Corn Products Refining Co., on power in the food industries, by V. D. Simons on power in paper making. At the afternoon session, 2 o'clock, S. G. Neiler will speak on developments in industrial power plants, C. H. Kane of Swift & Co. on the use of power in the meat packing industry and J. H. Lendi of the Universal Portland Cement Co. will give a paper on power in cement mills.

Thursday morning at 10 o'clock, Samuel Insull, Jr., will address the Conference on the co-ordination of gas production and electric power supply and it is expected that Paul Clapp of the National Electric Light Association will furnish a paper on the changes in industrial and social conditions due to larger use of power.

In the afternoon, inspection trips will be made to the works of the Illinois Steel Co. at South Chicago and to the Calumet Station of the Commonwealth Edison Company.

Friday morning's meeting will be devoted to coal, a paper by Samuel A. Taylor on coal for central station plants and one by F. S. Collings of Sargent & Lundy on recent developments in coal burning.

Inspection trips will be arranged for the afternoon to By-Products Coke plants of the Peoples Gas Light & Coke Co., and to the Crane Company's plant.

Thursday evening a banquet will be held at the Palmer House with address by Samuel Insull.

EXHIBITS WILL BE UNIQUE

In the exhibit halls of the Coliseum will be gathered the latest in equipment and appliances, all on one floor and in pleasing and convenient arrangement. Details will be as given in the following list:

AERO PULVERIZER CO., 90 West St., New York, N. Y. Booths 164-5.

Construction and method of action of a complete Aero unit coal pulverizer will be exhibited, with parts of the pulverizer showing the endurance after having been a long time in service. Photographs and drawings of installations and parts will be included.

AIR PREHEATER CORP., 25 Broadway, New York, N. Y. Booth 55.

Working model will be shown of the Ljungstrom air preheater and exhibit will be made of the Howden air compressor and other apparatus used for forced draft systems. Demonstration of the regenerative system of air heating will be given.

ALEXANDER BROS., 14 South St., Philadelphia, Pa. Booth 107.

Here will be shown a short center drive from an electric motor to a B. F. Sturtevant fan, featuring the Tentacular system. The exhibit will demonstrate, by means of a tachometer, that the belt does not slip even though the distance between pulley centers is unusually short.

THE ALLEN-SHERMAN-HOFF CO., 261 S. 15th St., Philadelphia, Pa. Booth 197.

Handling ashes by means of the hydrojet system with its type C water collecting ash gates will be demonstrated, also the use of quenchers, and of cast-iron coal bunkers and accessories. Details of the system will be fully shown and the construction of all parts of the system will be made clear.

ALLIS-CHALMERS CO., Milwaukee, Wis. Booths 82-4.

Represented in this exhibit will be the entire line of power plant equipment made by the company including steam turbines, water turbines, gas engines, steam engines, electrical machinery, pumps, air compressors, transmission equipment and special machinery for mining and metallurgical work; also details of flour mill construction and plants for timber preservation.

ALPHONS CUSTODIS CHIMNEY CONSTRUCTION CO. Booth 459. Material and methods of construction for hollow tile chimneys.

AMERICAN ARCH CO., INC., 15 E. 42nd St., New York, N. Y. Booth 322.

Construction of suspended arches of angle iron carried on cross-pieces will be shown, also the method of supporting the arch by steel clips and the construction of interlocking pillar tiles. The ease of renewal of any section will be clearly demonstrated.

AMERICAN BLOWER CO., 6004 Russell St., Detroit, Mich. Booths 182-3.

This company will exhibit its air filter of individual cells supported in steel framework. Details of the filter cell construction will also be shown and the method of using these air filters for ventilation and for generator cooling installations.

AMERICAN BROWN BOVERI ELEC. CORP., 165 Broadway, New York, N. Y. Booths 301-5.

This corporation will exhibit, in connection with its associated companies, including the Railway & Industrial Engrg. Co. of Greensburg, Pa.; the Moloney Elec. Co. of St. Louis, Mo.; The Condit Electrical Mfg. Corp., Boston, Mass. The Railway & Industrial Engrg. Co., will show outdoor substation equipment including disconnect switches, air break switches and the Franklin line of indoor switching equipment. Moloney Elec. Co. are builders of transformers and will display its product and illustrate methods of construction and installation. Condit Electrical Mfg. Corp. will exhibit switch gear, including oil switches, oil breakers, circuit breakers, switchboard and allied equipment. American Brown Boveri Electric Corp. will show a mercury arc power rectifier of steel enclosed type for converting any type of a.c. to d.c. and in capacities up to 1000 kw.

AMERICAN PULVERIZER CO., 18th and Austin, St. Louis, Mo. Booths 86-9, 124-7.

This exhibit, which will be in the space of Ernest E. Lee Co., will include a model to one-quarter scale of an American Ring crusher in operation, also photographs of American Ring crushers and parts of crushing machinery.

AMERICAN SCHAEFFER & BUDENBERG CORP., 338 Berry St., Brooklyn, N. Y. Booth 172.

This company will show its standard line of industrial instruments for indicating and recording pressure, temperature and speed. This will include gages, dial and straight scale thermometers, hand and stationary tachometers, also a line of steam traps, engine indicators, gage testers, pump, safety and water release valves, revolution counters, humidity controllers.

AMERICAN STEAM PUMP CO., Battle Creek, Mich. Booth 34.

Among the novel features of this year's exhibit will be the Barton portable pump which is made to attach to 28 different makes of automobiles, trucks and tractors. It is driven from the front end of the crankshaft of the machine to which it is attached, each pump being equipped with automatic primer, using the vacuum induced by the manifold of the motor for priming. This pump is for various uses, ranging from ditch pumping to fire fighting and will be displayed attached to a Ford chassis with motor in operation to demonstrate the operation and self-priming feature.

ANDREWS-BRADSHAW CO., 530 Fourth Ave., Pittsburgh, Pa. Booths 189-90.

Here will be shown a Tracyfier in operation, in a boiler drum with glass ends, simulating boiler conditions as closely as possible, and permitting observation of the action. Also will be shown sections of the Tracyfier disassembled so that the method of operation can be examined and studied.

ARMSTRONG MACHINE WORKS, Three Rivers, Mich. Booths 403-4.

On exhibit at the show will be various sizes of Armstrong traps of both cast iron and steel construction, a sectional model of the new compound trap recently put on the market for quickly handling large volumes of condensate as in the case of steam separators and an exhibition outfit showing the operation of the Armstrong trap by means of a glass model operating on steam pressure. The exhibit will be more in the nature of an educational proposition than for selling. One of the booths will be used as headquarters for Armstrong representatives and Armstrong trap users.

THE ATLAS LUMNITE CEMENT CO., 25 Broadway, New York, N. Y. Booth 328.

Explanation will be made of the uses of Lumnite cement for rapid construction of concrete foundations and for use in cold weather construction. Literature will be available showing instances of construction and use within 24 hr. which has been made possible for even heavy load bearing foundations by means of this cement.

ATWOOD & MORRILL, Salem, Mass. Booth 87.

Here will be shown turbine and condenser valves for high temperatures and pressures, also special valves for low-pressure superheating work and demonstration will be made of a new damper regulator.

AUBURN STOKER CORP., 8 S. Dearborn St., Chicago, Ill. Booth 334.

Here will be found an entirely new line of apparatus in the form of Auburn full mechanical stokers. A full size 150-hp. stoker will be in operation, showing details of construction and just how the stoker functions.

AUTOMATIC PRIMER CO., 111 W. Washington St., Chicago, Ill. Booth 122.

Here will be found an exhibit consisting of an Apco primer for centrifugal pump, direct connected to a horizontal centrifugal pump and motor, operating as a typical horizontal sump pump until controlled by a float switch. The primer works intermittently, pumping water from a sump and illustrates the ability of horizontal pumps to lift water by suction when properly primed, no foot valves or other means of priming being used.

BABCOCK & WILCOX CO., 85 Liberty St., New York, N. Y. Booths 145-156.

Construction of water tube boilers and superheaters will be demonstrated and illustrations shown of the installations made in numerous of the large central stations throughout the country.

E. B. BADGER & SONS CO., Boston 14, Mass. Booth 339.

This company will exhibit its line of expansion joints and spray nozzles including each type of expansion joint, the self-equalizing type for welded steam lines, the same type fitted with monel-metal sleeves for superheated steam and high temperature fluid lines; also a sectional joint and a complete line of both Turbine center and non-clog nozzles.

BAILEY METER CO., E. 46th and Euclid Ave., Cleveland, Ohio. Booths 153-6.

Equipment on display by this company will include a number of different styles and sizes of meter panel boards, as well as a complete line of Bailey boiler meters, fluid meters, pressure and temperature recorders, tachometers and multi-pointer gages. A feature of special interest will be a section of Pyrex glass pipe through which water will be circulated at various rates of flow to demonstrate the operation of an orifice type meter and to show the effect of various pipe fittings upon the flow of fluids. Bailey meter control for automatically regulating supply of fuel and air to boilers according to the demand for steam will also be in operation, demonstrating the effectiveness of this equipment.

BARCO MFG. CO., 1801 Winnemac Ave., Chicago, Ill. Booth 199.

Flexible joints for oil, steam, water, air, gasoline and other fluids will be shown, also the construction of the spherical packed bearing for these joints and details of the Barco balanced and lubricated plug valve which is lubricated under pressure to prevent sticking.

BARRETT-CHRISTIE CO., 37 S. Clinton St., Chicago, Ill. Booths 400-2.

In this exhibit will be included Armstrong steam traps, Lumen machine bronze and a display of the Wood Shovel & Tool Company's Molybdenum shovels and scoops. Other features will be the Instant Water Heater, Durabla sheet and rod packings and high-pressure gage glasses.

THE BARTLETT HAYWARD CO., Baltimore, Md. Booth 460.

Adaptability of the Fast's couplings, of which the standard form is familiar, will be demonstrated under special conditions. This will be accomplished by models of special forms with cut-away section to show the cut-out or disconnecting type, telescopic type, water and dust-proof type, heavy duty coupling for moderate speeds and coupling designed for use with tapered motor shafts.

THE BAYER CO., 4067 Park Ave., St. Louis, Mo. Booth 325.

The model K-2 soot blower for all types of boilers with valve in the head will be shown, also a special attachment to the blower head for providing air circulation through the blower element when not in use. Details of blowing systems and the action of the special controls will be fully illustrated.

BEARIUM BEARINGS, INC., 29 Broadway, New York, N. Y. Booths 320-1.

In this exhibit will be found rough and machined bearings for all types of service and demonstration of the nonscoring, non-seizing emergency feature of the Bearium metals when run at high speed without lubrication.

R. H. BEAUMONT CO., 319 Arch St., Philadelphia, Pa. Booths 138-9.

A complete coal and ash-handling system will be shown centralized in one point with all units in operation demonstrating the ease and simplicity of handling coal and ashes in the modern plant. Coal is received in a railroad car, discharged into a track hopper, then passed to the skip bucket by means of the patented Simplex loader. It is elevated by this bucket and discharged to the tram-car which conveys it over the bunkers and discharges at any desired location. From the bunkers a weigh larry distributes to the stokers as needed. Surplus above that required to fill the bunkers is deposited in coal storage and is spread out and reclaimed by means of drag scrapers. Ash passes from the stokers

to copper steel ash hoppers, whence it is discharged to an ash larry, then to the skip hoist and elevated to the ash bunker for discharge to railroad cars. One of the outstanding features is the Beaumont tram-car which will be shown in actual operation, timed to function in step with the travel of the skip bucket.

Bernitz Furnace Appliance Co., 80 Federal St., Boston, Mass. Booth 335.

This exhibit will include a full-sized layout of S-100 series Bernitz Carbofrax super block and part of a layout of pulverized fuel furnace lining. Each material will be shown in typical use for furnace construction. Other standard ventilating blocks and shapes will be included in the exhibit.

Bethlehem Steel Co., Bethlehem, Pa. Booths 63-7.

Here will be featured the new Bethlehem pulverizer and also the Bethlehem Dahl oil burner. Included also in this exhibit will be the Bethlehem turbo feed pump, Pervac extraction pump and the Bethlehem oil engine in both large and small units. The Diesel engines will be represented by large photographs and by a special Diesel engineer. Detailed parts and detail construction of all apparatus will be fully illustrated.

actual operation will be a new design Cat-a-ract low-pressure steam trap, designed for large capacity to discharge condensate.

The Bristol Co., Waterbury, Conn. Booth 300.

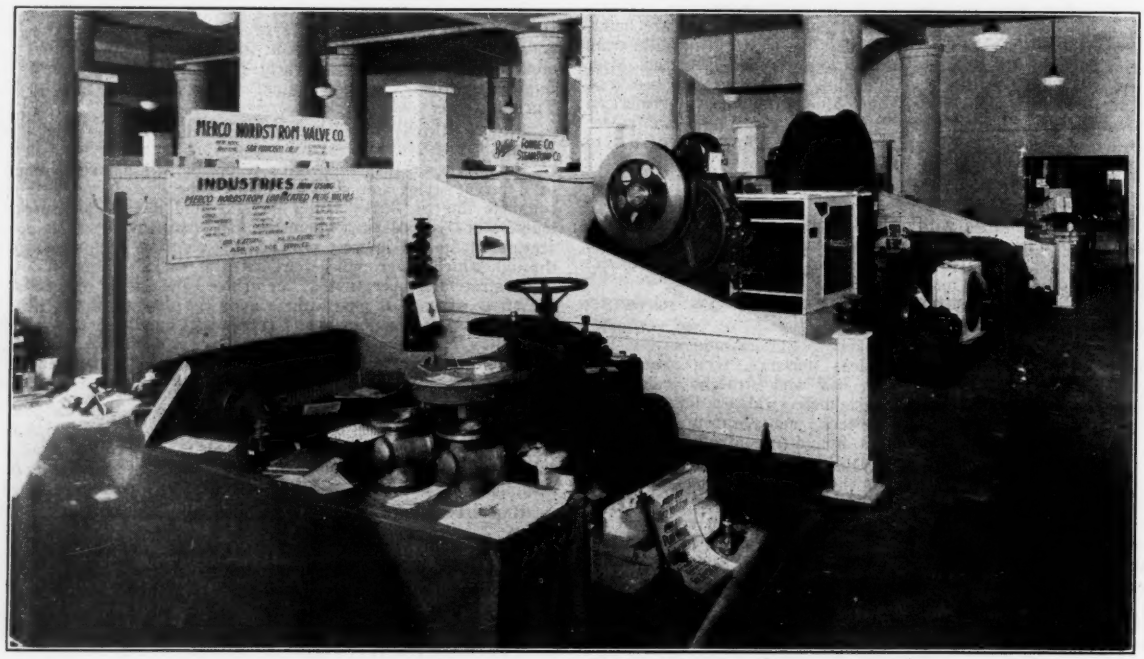
In this exhibit will be covered a complete line of recording instruments for the power plant; pressure and vacuum gages; pyrometers, water level gages, voltmeters, ammeters and wattmeters. The Bristol-Deer water level gage for steam boilers will be a special feature and can be operated at any convenient point at any distance from the boiler.

Wm. Bros. Boiler & Mfg. Co., Nicollet Island, Minneapolis, Minn. Booth 426.

Three and four-drum water tube boilers of bent tube design will be exhibited, also a full line of fire-box heating boilers especially of the welded type. The special feature will be the water-tube type with details of construction clearly shown.

The Brown Instrument Co., 4578 Wayne Ave., Philadelphia, Pa. Booths 15-16.

In this display will be illustrated the basic operating principle of the new Brown electric flow meter using the inductance bridge. A number of models of the meter will be shown, including the



A. VALVES, PUMPS, BLOWERS AND FURNACE MATERIAL WILL BE LARGELY REPRESENTED

The Bishop & Babcock Sales Co., 4901 Hamilton Ave., N.E., Cleveland, Ohio. Booth 448.

The display will consist of the following equipment: Automatic temperature control board, showing the operation of Bishop & Babcock temperature regulation; Massachusetts modified Type V unit heaters; Massachusetts modified squirrel cage fan, and a Texrope drive with squirrel cage fan direct connected to motor. This will be the initial showing of the Massachusetts unit heaters.

Botfield Refractories Co., Philadelphia, Pa. Booth 440.

This company will exhibit its product, Adamant fire brick cement including the single ring arch in which about 150 lb. of refractory brick is supported by a thin layer of cement. Also display will be made of the various uses for this cement in boiler furnace fire brick construction and data on representative power plants in the middle west.

S. F. Bowser & Co., Inc., Fort Wayne, Ind. Booth 338A.

The Bowser and Richardson-Phenix systems for lubrication, oil filtration and storage of oil, demonstration being made of the operation of complete systems.

Boylston Steam Specialty Co., 116 Illinois St., Chicago, Ill. Booth 41.

In this booth will be found a full line of steam plant devices including the Boylston improved steam trap shown in detail, also a sectioned model of the pressure-regulating valve. Other features will be back-pressure valves for universal application, tank valves, temperature controllers, strainers and water sprays and pump governors. Section will be shown of a self-contained, non-cut, single-seat, pilot-operated pressure-regulating valve and in single and duplex indicator with circular and strip recording charts. Another important feature will be latest models of the electric CO_2 meter with indicator either at the boiler front or on the switchboard and double scaled to indicate CO_2 and flue gas temperature. Other instruments shown will be pyrometers, resistance thermometers, pressure gages, and draft gages.

Buffalo Forge Co., Buffalo, N. Y. Booth 99-101.

This company will exhibit pumps for power plants, mechanical draft equipment, ventilating and heating equipment, and a combination iron worker.

Builders Iron Foundry, Providence, R. I. Booth 168.

In this exhibit will be found a type M register-indicator-recorder in operation with Venturi tube to show the method of indicating and recording the flow of fluids; a barometric manometer and a cast-steel venturi tube and type N nozzles. Details of the Venturi method of metering fluids will be shown as well as the method of operation.

Bundy Steam Trap Co., 26 Cortland St., New York, N. Y. Booth 432.

Steam traps will here be shown, functioning under typical power plant conditions, with new improvements such as ground joints at trunnion and elbow connections to eliminate vibration. Other features are combination of bowl, feed and discharge pipes and elbows, knife edge bearings for the bowl, lever and connecting rods and monel valve seats and discs.

Burke Engineering Co., Holland, Mich. Booths 120-1.

Working exhibit will be shown of the company's new underfeed stoker which is the improved Roach stoker. It is of single

retort form with side ash dump. In addition there will be a display of the Burke traveling grate stoker of which the grate surface is not a part of the endless chain mechanism. Also the company's hand-operated stoker and the U. S. Rocking grate with clips carried by transverse bars.

BURNHAM, BLAND & LINDSEY, 208 S. LaSalle St., Chicago, Ill. Booths 435-8.

This company represents the Vulcan Soot Cleaner Co. of DuBois, Pa., exhibiting soot blowers and soot blower control valves; Ross Heater & Mfg. Co. of Buffalo, N. Y., exhibiting oil vapor condensers and guided expansion joints; the Moore Steam Turbine Corp. of Wellsville, N. Y., exhibiting centrifugal boiler feed pumps and steam turbines; the Centrifix Corp. of Cleveland, O., exhibiting a steam purifying system; Smith Gas Engineering Co. of Dayton, O., exhibiting gas producers and engines.

CARRICK ENGINEERING CO., 538 S. Clark St., Chicago, Ill. Booth 195.

Here will be demonstrated chronometer valves furnace regulators and mercury actuated master control for furnace regulation. In a glass enclosure will be exhibited a working model of the master control to show action of the mercury column which is used in place of springs or diaphragms.

CARTER BLOXONEND FLOORING CO., 902 Walnut St., Kansas City, Mo. Booth 167.

This company will exhibit flooring panels made up from standard 8-ft. lengths of Bloxonend to illustrate the simplicity of laying this floor over old or new concrete or wood floors. The flooring is primarily for factory use.

THE CASEY-HEDGES CO., Chattanooga, Tenn. Booth 202.

Working model will be shown of the Casey-Hedges Multipass boiler demonstrating the principles employed, also photographs showing boilers in plants which are in operation. The booth will be specially fitted up as a headquarters and rest station for friends of the company.

A. W. CASH CO., Decatur, Ill. Booth 185.

Combustion control by the Craig system will be demonstrated including the Type S master control actuated by steam pressure, forced draft fans, stoker pistons and boiler uptake damper. A complete line of pressure regulating devices as manufactured by this company will be shown in model form.

CELITE PRODUCTS CO., 1320 S. Hope St., Los Angeles, Calif. Booth 453.

Here will be shown a small demonstration furnace, illustrating the difference in conductivity through insulated and uninsulated construction. A sample furnace wall will show standard methods of installation, while blue prints and charts will further develop these methods. In addition, a complete display of Sil-O-Cel insulating brick, block, powder, cement and aggregate will be shown, as well as Celcote air-sealing compound and Fraxite refractory cement.

CENTRIFIX CORP., 3029 Prospect Ave., Cleveland, O. Booths 173-4.

Complete exhibit will be made of the different types and designs of centrifugal apparatus for purification of steam and compressed air, the recovery of entrainment in evaporating processes and the removal of dust from air and gases. All these devices use the principle of centrifugal force without moving parts. One feature will be the latest development which makes it possible to discharge the moisture separated from the steam back into the drum rather than through external trap connection.

THE CHAPMAN VALVE MFG. CO., 203 Hampshire St., Indian Orchard, Mass. Booths 5-5½.

At this exhibit will be found a line of chrome nickel-steel gate valves and fittings for high pressure and temperature service; also the Chapman motor unit applied to a valve, connected for operating demonstration and a line of iron-body gate valves for water and steam service. Information will be available in regard to research work on material for power plant service with complete report on the causes of bolt failures under severe conditions.

CHICAGO CHEMICAL CO., 6216 W. 66th Pl., Chicago, Ill. Booth 108.

This company's exhibit at the show will include a section of a Stirling type boiler made of glass and demonstrating the water-treating qualities of K. W. S. Sodium Aluminate. Display will also be made of water-testing equipment for boiler plants to determine the effectiveness of the softening treatment and to determine the treatment needed by the raw water.

CHICAGO PUMP CO., 2336 Wolfrom St., Chicago, Ill. Booths 203-4.

In this space will be shown a large pumping unit in operation demonstrating the action of the Flush-Kleen sewage ejector and showing the principle on which the apparatus operates. Two other pumping units will also be displayed, also five multi-stage horizontal pumps and seven single-stage horizontal pumps, two vertical pumps and several heating pump units.

CLARAGE FAN CO., Kalamazoo, Mich. Booth 175-6.

Specialty features in this exhibit will be a type V air washer with all accessories, the new HV multiblade fan for heating and ventilating work, a new type FD high-speed blower equipped with ball bearings and Alemite greasing attachment, type V steam engine for operating stokers, fans and other plant accessories in capacities of 5 to 85 hp. and using steam with pressures from 40 to 250 lb. The high-speed forced draft fan is designed with rising pressure curve to assure ample air supply with heavy fuel bed and the steam engine has, as a special feature, an automatic lubricating system. Other items included will be blast gates, dampers, ventilators and exhaust fans for powdered coal systems.

THE CLEVELAND WORM & GEAR CO., 3249 80th St., Cleveland, O. Booth 444.

This exhibit will include a standard type AH unit driven by a small motor through a size O type RT worm gear reduction unit, also samples of worm gears and bearings for standard Cleveland worm gear reduction units.

COCHRANE CORP., 17th St. below Allegheny, Philadelphia, Pa. Booths 446-7.

Deaerating equipment, complete with vent conducter will be shown for operation under vacuum, back pressure or atmospheric pressure. Back washing and filtering are secured by the use of a single valve through a strainerless conical filter. Indicating and recording flow meters will be exhibited, records of pressure or temperature recording pen being on the same chart as those for the flow-meter pen. Multiport back pressure valves and high-pressure and low-pressure traps will be included in the exhibit, also a sectioned steam oil separator of horizontal type.

COKAL STOKER CORP., 400 N. Michigan Ave., Chicago, Ill. Booths 129-31.

Pulverzone stokers will be displayed at this space having overhung arch, turbulators, power feed, hopper and dumping plate. This stoker maintains two complete combustion zones for burning lumps and fines separately, it can also be operated as a stationary grate with firing doors or as a shaking grate.

COLUMBIA VARI-SPEED CO., 4020 W. Lake St., Chicago, Ill. Booth 173½.

This company will display the JFS variable speed transmission of totally enclosed type, capable of receiving power from a motor direct connected to a constant speed shaft and transmitting power at variable speeds, all in a straight line. It is made in a reduction from motor speed as low as 40 to 1, with variable features. Internal parts, which are only four in number, will also be shown. Various size units will be demonstrated in actual operation.

COMBUSTION ENGINEERING CO., 200 Madison Ave., New York, N. Y. Booths 8-9, 30-33.

Three displays showing equipment as in operation will be made, one of a Lopulco equipped furnace and boiler unit; one showing the combustion steam generator; one showing an application of the Couch burner for horizontal firing, in a boiler and furnace setting representative of the most recent practice. This last display has recently been completed. Included in this exhibit will be a No. 55 unit system pulverizing mill with cyclone separator of impact type as installed in a large number of plants; a No. 5 Couch burner for horizontal firing of pulverized fuel, with capacity of approximately 10,000 lb. of coal an hour; a Green forced draft stoker in section and in detail; a C-E air heater in model form with a number of elements installed in a casing; model of a C-E fin furnace having self-supporting type of wall construction. Photographs and drawings will also be shown, especially one, a colored sectional view of a steam generating unit installed in the Kips Bay Station of the New York Steam Corp. and another a colored sectional view of a specially designed furnace and boiler unit recently developed.

CONDIT ELECTRICAL MFG. CO., Boston, Mass. Booth 302.

Here will be displayed a single pole 600-amp. 15,000-v. electrically-operated oil circuit breaker with frame and tank cut-away to show rigid design. This device has interrupting capacity of 6000 amp. at 15,000 v. Also a 3-pole single-throw oil circuit breaker with interrupting capacity of 3600 amp. at 15,000 v., a motor starting panel with 4-pole double-throw oil motor starter for 300 amp. and with interrupting capacity of 2700 amp. at 2500 v. It is arranged for 3-wire operation on either 3-phase or 2-phase circuit. Another feature will be control relays for use with solenoid-operated air or oil circuit breakers. The circuit is broken from rolling contacts with an arcing horn between magnetic blowouts. Control relays will carry 50 amp. continuously and make or break 200 amp. at 125 v. or 100 amp. at 250 v.

CONNERY & CO., 2nd St. Above Erie Ave., Philadelphia, Pa. Booths 116-17.

Typical smoke breechings for power plants will be shown, constructed with Connery's improved expansion stiffener in place of angle reinforcement. This stiffener is electrically welded instead of riveted. Included in the exhibit will also be the air-cooled damper and the company's method of supporting and applying

asbestos covering to smoke breechings by means of a patented attachment for the covering support.

COOKE SEAL RING, INC., 30 N. Green St., Chicago, Ill. Booth 172½.

Details will be shown here of the construction of this method of sealing rods and shafts which eliminates the use of packing.

COPPUS ENGINEERING CORP., Worcester, Mass. Booth 22.

Included in this exhibit will be the Coppus Vano blowers, steam turbine, air turbine or electric motor-driven for use with stokers or in pipe lines; also the turbo blower type C for undergrate draft which is steam turbine-driven and supported on ball bearings.

CRANDALL PACKING CO., Palmyra, N. Y. Booth 205½.

All brands of Crandall packings in sheet, rod, gasket and other forms will be found displayed in this exhibit.

CRANE CO., 836 S. Michigan Ave., Chicago, Ill. Booths 1-2.

Here will be found steel valves trimmed with stainless steel, a recent development in the way of valve trimming for high-pressure, superheated service. Also forged steel gate, globe and check valves, forged fittings and flanged unions. Steel valves made by a process which gives uniform thickness of metal will be shown, also valves with bolted bonnet as well as with union bonnet. These valves are specially designed and are suitable for extremely high pressures and temperatures.

CRANE PACKING CO., 1800 Cuyler Ave., Chicago, Ill. Booth 434.

This company will show a condenser model with the tubes expanded at one end and packed with metallic packing, without the use of ferrules, at the other end, an electric expanding tool, and a demonstration condenser will be provided to show how tubes packed at both ends can be expanded at one end and packed with metallic packing at the other end. Metallic packings will also be displayed covering styles for steam, air, ammonia, hot oils, gasoline and other services with complete models of ammonia sets.

CROSBY STEAM GAUGE & VALVE CO., 612 Marshall Bldg., Boston 8, Mass. Booth 179.

In this exhibit will be found Nickeloy globe valves, bronze, monel and steel valves, a machine for testing gages up to 25,000 lb. per sq. in., special valves for pressures up to 900 lb. and cast-steel and monel metal valves for special high pressure service.

THE CUTLER-HAMMER MFG. CO., Milwaukee, Wis. Booths 312-13.

Four items of the latest design will be shown including the type B automatic starter, a type C across the line starter, No. 9621 automatic starter. In addition, the regular A-2 Dean unit for valve control will be demonstrated. The type B starter is 3-pole design, with added overload protection. Type C starter is designed to handle motors taking up to 250 amp. No. 9621 automatic starter is 3-pole and is of compensator type. It has overload protection, by means of the C-H thermal overload relay. The Dean valve control unit will be shown mounted on an Edwards Valve & Mfg. Co.'s valve, and will be in operation, showing the method of opening and closing. A building equipment panel will include all of the popular C-H building equipment apparatus and some smaller articles will be shown, such as space heater, tubular heaters and the like.

THE CUTTER ELECTRICAL & MFG. CO., 19th and Hamilton Sts., Philadelphia, Pa. Booths 310-11.

As features of this exhibit will be found a 6000-amp. type LG, 3-pole carbon circuit breaker, arranged for solenoid operation and non-closable on overload at any point of the closing stroke. This will be a massive apparatus and will have as a background a 600-amp. 3-pole a.c. circuit breaker; a 1000-amp. auto U-Re-Lite for 550-v. a.c. service; a 3000-amp. single-pole toggle switch; an 800-amp. single-pole circuit breaker with field discharge clips for use with motor or generator field circuits; a 60-amp. junior and a 150-amp. senior U-Re-Lite; a 1250-amp. NX U-Re-Lite.

G. M. DAVIS REGULATOR CO., 422 Milwaukee Ave., Chicago, Ill. Booth 45.

Here will be displayed full-sized models of Davis valve specialties for automatic regulation of pressure, including pressure regulators, float valves, back pressure valves, stop and check valves, steam traps and a new wing disk check valve.

THE DELAVAL SEPARATOR CO., 165 Broadway, New York, N. Y. Booths 134-5.

Oil purifying apparatus will be featured in this exhibit, particularly the purification of turbine oil and also the dehydration of transformer and circuit breaker oils. Equipment used for dehydration in open type transformers will be demonstrated, as well as that used for purifying oil in the conservator or inert air type.

DELTA STAR ELECTRIC CO., 2435 Fulton Ave., Chicago, Ill. Booths 316-17.

Equipment will be shown for unit type standardized sub-stations including steel towers, choke coils, mountings and switching units.

M. H. DETRICK CO., 140 S. Dearborn St., Chicago, Ill. Booths 149-50.

Here will be shown sectionally-supported side walls of the company's make especially adapted for pulverized fuel boiler settings; also the Detrick flat suspended arch with details of construction, photographs and drawings of walls and arches adapted to various makes and types of boilers.

DETROIT STOKER CO., General Motors Bldg., Detroit, Mich. Booths 177-8.

In this space will be found a complete full-size underfeed stoker in operation, demonstrating the principles of its underfeed forced draft multiple retort design; it will have worm gear drives with adjustment for controlling the stroke of the pusher rod and the working out of draft control will be clearly shown.

DIAMOND POWER SPECIALTY CORP., Detroit, Mich. Booth 140-1.

An attractive feature of this exhibit will be a miniature boiler by means of which the principles of correct application of soot blowers to varying boiler conditions will be demonstrated. Effects of soot deposits in retarding heat transmission will be shown, also the benefits secured by soot removal. Motion picture films will be displayed in addition, showing the uses and benefits of soot blowing on oil-fired boilers, these films having been made by the U. S. Navy and used as part of its training course in boiler-room practice.

DINGS MAGNETIC SEPARATOR CO., 222 Smith St., Milwaukee, Wis. Booth 126.

Demonstration of the operation of the Dings Magnetic pulley for removing tramp iron from coal, also features of Magnetic separators for iron, steel and brass foundries, suspended type magnets and magnetic concentrators of different types.

JOS. DIXON CRUCIBLE CO., Jersey City, N. J. Booth 12.

Dixon graphite products, including Ticonderoga flake graphite, Silica graphite paint, Aluminum graphite paint, solid belt dressing, graphite cup grease, water proof and graphite greases, graphite pipe joint compound and other graphite products will make up the exhibit in this space. An interesting feature will be a special machine built to show the temperature and load on the bearings lubricated with greases and other lubricants.

DODGE MFG. CORP., Mishawaka, Ind. Booths 418-20.

This company will arrange an attractive exhibit covering its Dodge-Timken cast-iron conveyor idlers, belt governors and loose pulleys, also its full line of products both in still display and actual operation. Several new developments in the material handling field will be shown. The company's line includes, besides the features already mentioned, cast-iron troughing idlers, roller-bearings units, ball socket roller-bearing pillow blocks and hangers.

C. A. DUNHAM CO., 230 E. Ohio St., Chicago, Ill. Booths 455-6.

Steam specialties for low and medium pressures including radiator traps, packless radiator valves, float and thermostatic traps, return traps, pump governors, oil separators and a damper control system.

THE EDWARD VALVE & MFG. CO., E. Chicago, Ind. Booth 52.

Here will be displayed the Edward forged steel valves in screwed end and flanged end designs and with union and bolted bonnets for various classes of service up to and including 1350 lb. In addition will be exhibited the company's line of Ferac non-return valves also special valves for oil refinery service illustrated by large sectional views mounted on panels.

EHRET MAGNESIA MFG. CO., Valley Forge, Pa. Booth 43.

Display of 85 per cent magnesia pipe covering and blocks, also high-temperature insulation in various mixtures and types. Illustration of the lightness, strength and permanent effectiveness of this material with details of the chemical and manufactured processes of producing it.

ELLIOTT CO., Jeannette, Pa. Booths 105-6.

This company's complete line of products will be illustrated, including strainers, filters, separators, preheaters, deaerators, turbines, generators, boiler tube cleaners and other specialties. A characteristically Elliott piece of apparatus shown will be the 100-kw. geared turbine-generator unit consisting of a Kerr steam turbine and a Ridgeway generator, with flexible coupling between the turbine and gears and also between the gears and alternator. Construction of the various products will be fully shown by means of cutout models and also by opening company machines for inspection.

LEWIS M. ELLISON, 214 W. Kinzie St., Chicago, Ill. Booths 200-1.

In this space will be found a new exhibit including the pointer draft gage, of gasometer ball and beam type with vertical space line reading scale, the U-path calorimeter for throttling, separating and re-evaporating in a single chamber and with steam jacket and insulating jacket of lamp black and a bridge surface casing to reduce radiation. A regular line of inclined and vertical draft gages will also be included in the exhibit.

Evens & Howard Fire Brick Co., St. Louis, Mo. Booth 166.
This company will display its standard grade of brick, showing a complete line of 9-in. "straight" and 9-in. "series" in Vulcan, Acme and St. Louis brands, also the E&H Texafrax and Durofrax brands which are made in Texas. Illustrations of central station plants built in the last 2 yr. in which the company's brick has been used will also be shown.

Everlasting Valve Co., 1 Exchange Pl., Jersey City, N. J. Booth 40.

The Scully Steel & Iron Co., western distributors of Everlasting Valves, will be in charge of this booth where will be displayed the Everlasting companion angle, which is offered as a companion to the regular Everlasting valve for boiler blowoff service. Valves will be on display to care for boiler pressures up to 500 lb. Another feature will be the Boiler Drawoff Wylie Wilson process for handling boiler blowoff at very high pressures, also the Everlasting tandem valve model X, a two-valve unit connected so as to remove any error in operation. The regular line of Everlasting valves and Flatplug valves will also be shown.

The Fafnir Bearing Co., New Britain, Conn. Booths 337-8.

Industrial applications for ball bearings, including hanger boxes, pillow blocks, machine bearings and radial and thrust bearings.

Fairbanks, Morse & Co., 900 S. Wabash Ave., Chicago, Ill. Booths 94-5, 118-9.

In this space will be found a 36-kw. cold-starting full Diesel engine generating set; a 25-hp. sectioned squirrel-cage motor, running on air and five other motors running on a.c. and d.c. current; a high-speed, high-head centrifugal pump in operation; a self-oiling power pump direct connected to motor; a quartered section moderate head centrifugal pump with rotating element; enlarged photographs of the details of Diesel engines. The 36-kw. full Diesel engine is a new development and will be specially featured.

The Fisher Governor Co., Inc., Marshalltown, Ia. Booth 410.

Pump governors, reducing valves, steam traps, float valves, liquid level controllers and other specialties will be included in this exhibit, the No. 240 liquid level controller being specially featured. This is actuated by sensitive bellows and liquid transmission and has valve located at a distance from the tank.

Foster Engineering Co., 108 Monroe St., Newark, N. J. Booth 459.

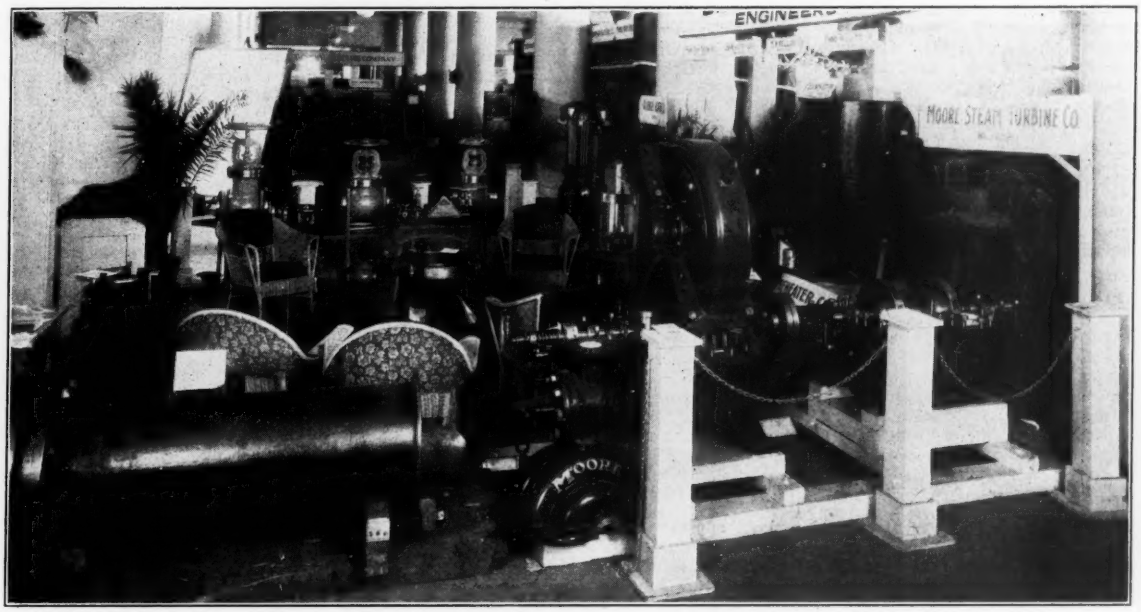
Pressure regulators for various services, pump governors for high-pressure service up to 400 lb. and superheated steam; also back pressure valves and relief valves of several types, float valves for steam and water, automatic stop and check valves for high pressures, non-return stop valves, fan engine regulators and the Foster flexible ball joints.

The Foxboro Co., Inc., Foxboro, Mass. Booth 26.

This company plans to have an educational demonstration of the important points of high-grade instruments. Tests will be run to show that temperature along the connecting tube of Foxboro thermometers has no effect on readings of the instrument, also to show that Helical movements can be overloaded 100 per cent without damage or affecting the calibration. Foxboro's new boiler water level gage will be attached to a standard water column and arranged so that visitors may change the water level and watch the immediate response from the gage. Flow meters and flow controllers will be displayed on a board, showing the advances recently made, also panels of the various products of the company will be in evidence. Of interest to engineers from the smaller plants will be a complete instrument installation on a single board containing a CO_2 recorder recording pressure gage, flue gas thermometer and a draft gage.

O. E. Frank Heater & Engineering Co., 20 Milburn St., Buffalo, N. Y. Booth 22.

This company's exhibit will consist of a new design of heat exchanger and oil cooler, a full-sized piece of equipment, disassembled to show all the advantageous features. Another feature will be a U-tube type storage heater cut in section to show the details of construction.



B. TURBINES, HEATERS AND ELECTRICAL EQUIPMENT DISPLAYED IN ATTRACTIVE SETTINGS

Fuller-Lehigh Co., Fullerton, Pa. Booths 145-8.

Models will be shown of the Fuller pulverizer mill, the Randolph vertical drier, and the Fuller pulverized coal burner. Also sections of the Bailey furnace wall, the Fuller-Kinyon pump, Bailey feeder and meter, Fuller single screw feeder, Calumet pulverized coal burner and blueprints and photographs of many recent Fuller-Lehigh installations. Construction and details will be fully shown and methods of operation demonstrated.

Furnace Engineering Co., Inc., 5 Beekman St., New York. Booths 78-9.

Demonstration will be made of the Simplex unit pulverizer with revolving hammers, air separator and fans in capacities from 1500 to 15,000 lb. of fuel pulverized in each hour.

General Electric Co., Schenectady, N. Y. Booths 74-77.

This exhibit will demonstrate in particular the construction and operation of flow meters, air-cooling systems for turbine generator ventilation, systems for motor and control equipment, brush shifting motors for a.c. generators. A special feature will be the operation of flow meters by steam generated in an electric boiler.

Graver Corp., E. Chicago, Ind. Booth 123.

Here will be exhibited a working model of the Graver water softeners with large colored drawings showing details of construction and method of installation of softening plants.

Grindle Fuel Equipment Co., Harvey, Ill. Booths 70-3.

Pulverized coal installation, hopper systems for firing boilers, cement kilns and furnaces of various kinds. Special emphasis will be placed on the unit pulverizer feeder and the Type Z feeder and burner for pulverized coal.

GRISCOM-RUSSELL Co., 90 West St., New York, N. Y. Booths 430-1.

Here will be shown Reilly evaporators, feed-water heaters and multi-well oil coolers; also U-fin generator air coolers, evaporators and Stratton steam and air separators. A special feature will be the Griscom-Russell bent tube evaporators with headers arranged vertically and held rigidly top and bottom so that bending of tubes, due to change of temperature, cracks off the scale.

HAGAN CORPORATION, Pittsburgh, Pa. Booths 27-28.

Apparatus to be exhibited in these booths will include the Hagan Steam purifiers, master regulator, combustion controller, roto valves, test cabinets, concentration gages, chemical pumps, and a combustion control system for individual boilers operated from a central panel, all boilers being operated simultaneously. This system is similar to an installation now used at the Port Morris Station of the New York Central Railroad.

THE HAYS CORP., Michigan City, Ind. Booth 324.

Here will be found a panel board of Hays pointed type gages in different cases and styles of mounting, using a special slack leather diaphragm to measure any range of draft or pressure from 1/10-in. water to 150-in. water and provided with illuminated scales and red indicating pointers. Sectioned model will be shown of the Hays automatic CO_2 and draft recorder to demonstrate the construction and accesibility. Other features of the exhibit will be the improved flue gas analyzer, combustion testing kit in portable form, which comprises the analyzer, metal armored flue gas thermometer and portable type draft gage.

ARTHUR HARRIS & Co., 212 Curtis St., Chicago, Ill. Booth 181½.

Here will be found a display of coils of various sizes and shapes made from copper, brass, aluminum and block tin tubing, also seamless copper ball floats for pressures up to 150 lb. Expansion joints for vacuum and low pressure will be shown and balanced valves of bronze piston type for feed-water heaters and tanks.

HIMELBLAU, AGAZIM & Co., 30 N. Dearborn St., Chicago, Ill. Booth 28.

Here will be found the steam engines of the Ames Iron Works; boiler baffles of the Boiler Engineering Co., Eclipse smoke indicators and McNeal liquid level gage of the Boiler Room Improvement Co.; blowers, pumps and turbines of the Coppus Engineering Corp.; cork isolation material of the Korfund Co., heating specialties of the Sterling Engineering Co.; packings and pump valves of the Witherup Cork Packing Co.

THE M. A. HOFFT Co., 814 W. Washington Ave., Indianapolis, Ind. Booth 187.

At the show this company will have a movie apparatus showing the repairing of an arch, also the cleaning of clinkers and ash from a stoker. Some grate bars and parts of a stoker and arch will be shown, also illustrations of the company's refuse conveying system.

HYDRAULIC PRESS MFG. Co., Gilead, O. Booths 13½-14.

Here will be exhibited a complete line of drop forged steel fittings for high pressure and temperature, also valves for similar conditions with bodies of drop forged steel. These have full steam opening, body of uniform section and renewable bevel disc and seat.

ILLINOIS ENGINEERING Co., Racine and 21st St., Chicago, Ill. Booths 405-6.

In this exhibit a special feature will be a ¾-in. No. 35 Eclipse steam trap in glass model form working under actual operating conditions. Instantaneous opening and closing of valves will be shown to demonstrate the extreme separation of valve and seat when open and that wire drawing or scoring of the seat is impossible. Complete steam and vapor specialties as manufactured by the company will be included in the display.

INGERSOLL-RAND Co., 11 Broadway, New York, N. Y. Booths 450-1.

This company will exhibit a complete line of Cameron pumps and will show by diagrammatic charts the features of its surface condensers. An important display will be a class "HMT" high-pressure multi-stage centrifugal boiler feed pump for operating pressures up to 1500 lb. A new detail of this pump is an improved thrust device having an hydraulic balancing drum keyed to the inboard end of the rotor to neutralize the thrust and eliminate high pressure on the stuffing box and supplementing this a Kingsbury thrust bearing incorporated with the outboard main bearing. Another pump shown will be the HW hotwell and condensate pump of horizontal volute type using two single-section enclosed impellers with opposed inlets so that the discharge of each impeller is in the direction of the nearest stuffing box, thus preventing infiltration of air and neutralizing practically all thrust. Special features of the surface condensers will be illustrated including the heart-shaped shell, tube staging, scientific proportioning of flow areas according to volume of steam, separation of steam condensation and of air devaporization and cooling by means of a separate external cooler, longitudinal division by steam-tight support plates into sections with separate vapor outlets to prevent formation of stagnant volumes of air and insure correct longitudinal distribution of the steam. A full line of descriptive literature will be available.

INSTANT WATER HEATER Co., 332 S. Michigan Ave., Chicago, Ill. Booth 401.

Heaters for instantaneous supply of water for house service in power plants.

INTERNATIONAL FILTER Co., 333 W. 25th Pl., Chicago, Ill. Booth 427.

Emphasis will be placed in this exhibit on a demonstration of a working model of a new International steam purifier of sectional form for installation in the steam space of boilers. Method of installation and the action of the purifier in taking impurities out of the steam will be shown.

THE INTERNATIONAL NICKEL Co., 67 Wall St., New York, N.Y. Booths 212-13.

Monel metal and pure nickel in commercial forms such as rod, sheet, tube, ingot, shot, etc., will be shown, also an interesting collection of sample parts from different manufacturers of power plant equipment showing the design and perfection of workmanship in machining, welding, forming, casting and other operations which is possible with the monel metal and pure nickel.

IRVING IRON WORKS, Long Island City, N. Y. Booth 433.

Here will be demonstrated the Vizabledge Safstep with special double crimp near the nose of the strap to aid a person using the stairs in seeing clearly the edge of the step. Standard Safstep construction will also be shown for stairs, platforms and runways.

JENKINS BROS., 80 White St., New York, N. Y. Booth 290.

Jenkins Bros. globe, angle and check bronze and iron valves will be shown and in addition bronze and iron gate valves, radiator valves and quick-acting valves. Jenkins Bros. brand of mechanical rubber goods, valve discs, packings, gaskets and pump valves and Moncrieff gage glasses will also be featured in the exhibit.

JEWELL ELECTRICAL INSTRUMENT Co., 1640 Walnut St., Chicago, Ill. Booth 323.

This display will consist of the Jewell electrical measuring instruments of portable and panel mounting type for industrial and radio use. A new display will be industrial meters which incorporate the desirable features found in other classes of Jewell apparatus.

JOHNSON SERVICE Co., Milwaukee, Wis. Booth 442.

Demonstration will be made of the action of the temperature control system for steam and hot-water heating and the details of the apparatus and of the installation fully displayed.

W. A. JONES FOUNDRY & MACHINE Co., 4401 W. Roosevelt Rd., Chicago, Ill. Booth 128.

Exhibit of this company will include its Spur gear and worm gear speed reducers, small transmission appliances and spur and worm gear high reduction combinations for large speed changes.

KELLEY VALVE Co., Grand Haven, Mich. Booth 23.

Here will be found a line of Kelley self-grinding globe and angle valves, in all the various types and materials of construction which the company manufactures. Kelley controllers will also be shown.

THE M. W. KELLOGG Co., 7 Dey St., New York. Booth 54.

Forged and welded steel headers, also tongue and groove flanged joints and the Kellogg construction for Van Stone pipe joints will be exhibited. An additional feature will be Kellogg copper-plated welded expansion joint.

KIELEY & MUELLER, INC. Booth 401.

This company will exhibit sectional views of its horizontal back pressure valve, stop and check valve, extra heavy high-pressure pilot regulating valve and special pressure reducing valve. Another feature will be a high-pressure return trap.

THE KORFUND Co., 235 E. 42nd St., New York, N. Y. Booth 28.

This company will exhibit a number of plates of different shapes and sizes to demonstrate the wide application which Korfund Foundation has for many purposes. Recently marketed Vibro-dampers for deadening vibration and noise will also be demonstrated, some of them in section cut open to show the construction clearly. A set of dampers will be demonstrated in actual operation under a machine.

THE LABOUR Co., Chicago Heights, Ill. Booth 469-70.

This company will exhibit a line of self-priming centrifugal pumps arranged for both permanent and portable use. One of these pumps will be in operation with glass suction lines to illustrate the ability of this pump not only to prime itself but to handle large quantities of air.

LADD WATER TUBE BOILER CO., First National Bank Bldg., Pittsburgh, Pa. Booths 8-9.

Construction of the Ladd water-tube boiler will be shown, also the special baffle tile and drawings and photographs of the three-drum, the heavy duty high arch and multi-drum types and of various arrangements of superheaters.

LAMONT CORP., 200 5th Ave., New York, N. Y. Booth 205.

Here will be found LaMont steam generators and Duplex steam-sealed valves. The steam generator has, as an outstanding feature, film evaporation with extremely rapid heat transfer.

THE LEAVITT MACHINE CO., Orange, Mass. Booth 125.

Dexter valve-reseating machines for globe and gate valves and pump valve seats. These will be shown in detail and the method of operation and perfection of their performance fully demonstrated.

ERNEST E. LEE CO., 115 S. Dearborn St., Chicago, Ill. Booths 86-9, 124-27.

In this booth will be found the products of the firms which this organization represents in the Chicago territory. Among these

LIPTAK FIREBRICK ARCH CO., Mexico, Mo. Booths 143-4.

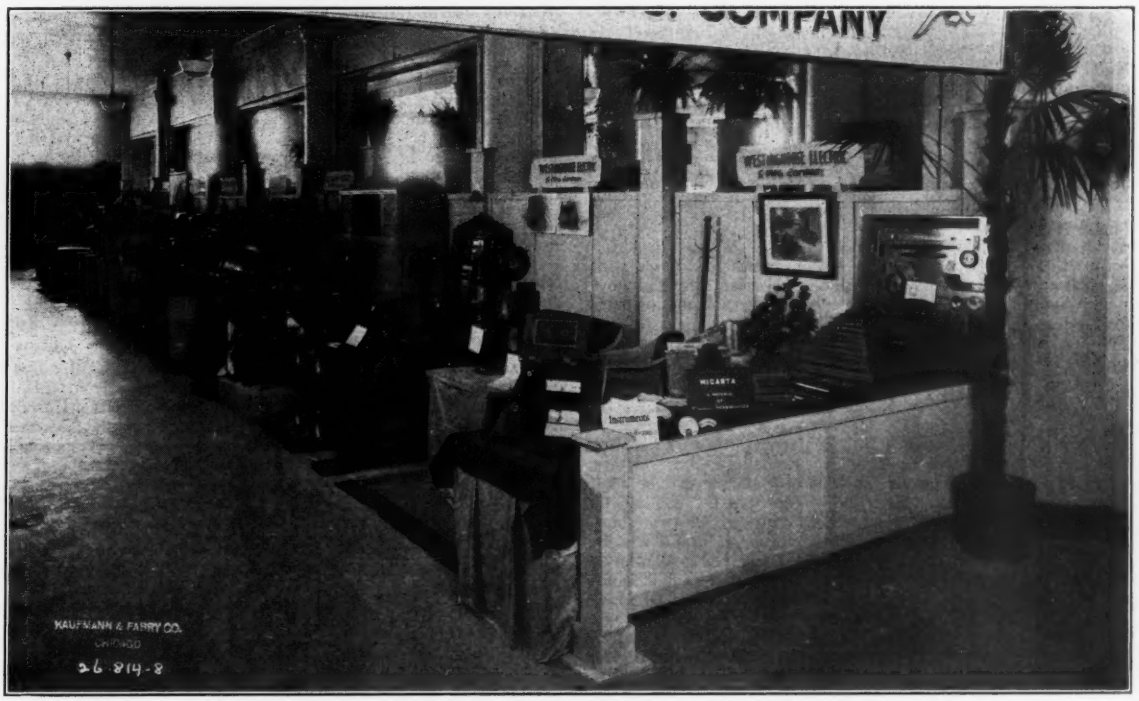
Here will be demonstrated arch and side wall construction for hand-fired, stoker-fired and pulverized coal furnaces. A special feature will be single and double-suspended arches, self-supporting side wall construction made of all refractory material, the side walls based on the double-suspended arch principle as adapted for powdered fuel burning.

LOCKE REGULATOR CO., Salem, Mass. Booth 432.

Balanced valves, reducing valves, the Locke damper regulator and the company's stop and speed-limit system will be shown here. The damper regulator is controlled by pilot valve, responding to slight changes in steam pressure and will handle all sizes of dampers from the smallest to the largest.

J. E. LONERGAN CO., 211 Race St., Philadelphia, Pa. Booth 432.

The Lonergan company will exhibit its line of iron-body pop safety valves, water relief valves, steam gages, clocks, water gage fittings and chime whistles, showing the various types with the details of construction.



C. EVERY AISLE WILL BE LINED WITH INTERESTING EXHIBITS

will be American ring coal crushers, the Allen-Sherman-Hoff ash sluicing system, Roturbo centrifugal pumps, Copes feed-water regulators, Leavitt valve reseating machines, Nitrose metal preservative, Uehling recording and indicating instruments, Dings magnetic separator and Atwood and Morrill relief valves and damper regulators.

LIBERTY ELECTRIC CO., Stamford, Conn. Booth 306.

Liberty valve operators will be shown in a 6-in. 600-lb. Walworth gate valve, operated from push-button station, also on a 6-in. 600-lb. Pittsburgh gate valve operated from a manual station. Actual functioning of the safety clutch will be demonstrated in preventing the breakage of valve stems or other damage to the valve, also the principle of operation of the cutout control.

GEO. B. LIMBERT & CO., 570 Fulton St., Chicago, Ill. Booths 92-3.

Special pipe bends, cast-steel fittings and other articles of power piping will be exhibited in screwed and flanged type, also brass and iron-bodied valves, Van Stone flanged joints, Chapman gate valves and Reading genuine wrought-iron pipe.

LINK-BELT CO., 910 S. Michigan Ave., Chicago, Ill. Booths 463-5.

Details will be shown of the company's equipment for handling and conveying coal, ashes and other material, also the systems of coal storing and reclaiming and the details of Peck carriers, skip hoists, intake screens and silent chain drives.

THE LUNKENHEIMER CO., Cincinnati, O. Booths 136-7.

In this exhibit the Lunkenheimer Co. will present representative steel, all monel, iron and bronze valves for pressures up to 900 lb., also steel monel mounted gate valves with Dean and Liberty electric control and, as one of the main features, a complete line of small all-monel gate, globe and check valves for 400 lb. pressure.

MANISTEE IRON WORKS CO., Manistee, Mich. Booth 88.

The Roturbo pump will be exhibited in 8-stage form, horizontally split; also a single-stage horizontal volute pump with horizontal split casing, a Roturbo impeller mounted on a stand to show details of construction and other detailed parts of the pump.

MANNING, MAXWELL & MOORE, INC., 100 E. 42nd St. Booths 19-20.

This company will exhibit its entire line of steam specialties including Ashcroft gages, Consolidated safety valves for high-pressure lines, Metropolitan injectors and Hancock valves in bronze, cast steel and forged steel.

MARION MACHINE, FOUNDRY & SUPPLY CO., Marion, Ind. Booths 407-8.

Demonstration will be made of a Type AD soot blower with independently-operated valve in the head and the action of the blower in cleaning tubes of water-tube boilers will be illustrated. Another feature will be the Marion Gulf-stream water heater for use in hotels, laundries and apartment buildings.

MERCO NORDSTROM VALVE CO., Peoples Gas Bldg., Chicago, Ill. Booth 157.

Here will be exhibited the Merco Nordstrom lubricated plug valve, designed so that it will neither stick nor leak due to the lubrication feature. The use of lubricant is designed also to reduce corrosion to a minimum, thus lowering maintenance cost. Valves will be shown in two-way, three-way and four-way types, made of all iron, of cast steel, and of nickel-bronze alloy.

THE MERCON REGULATOR CO., 53 W. Jackson Blvd., Chicago, Ill. Booth 52.

All types of pressure regulators for pressures up to and including 900 lb. at temperatures of 750 deg. will be exhibited, also the Mercon pressure regulator as used in conjunction with any water level control to maintain constant drop in pressure across the regulator. An additional feature will be a pump governor for steam-driven boiler feed pumps with cast-steel body, monel trim and built for 900 lb. standard, one of the largest steam-driven pump governors built.

MERRICK SCALE MFG. CO., Passaic, N. J. Booth 308.

Demonstration will be made of a conveyor scale in operation weighing out actual material. Another feature will be a recent production, the Merrick Mechanical Weighman giving automatic record of loads which pass across it.

THE MIDWEST PIPING & SUPPLY CO., 1450 S. Second St., St. Louis, Mo. Booth 161.

Joints designed to handle pressures up to 900 lb. and superheated steam to temperatures of 750 deg., employing neither gaskets nor field welding will be shown in this exhibit. Modifications for high pressure drip and drain lines will be shown, also the results of tests on the metal in various types of joints by the photographic process. An interesting feature will be a joint deflected to 3 deg. and under pressure of 2000 lb. showing that accurate alinement is not necessary.

MOORE STEAM TURBINE CORP., Wellsville, N. Y. Booth 436.

Featured in this exhibit will be a 4-stage boiler feed pump with double suction, driven by 5-stage turbine. Also an oil relay governor with hydraulically-operated valve, both governor and oil pump being driven by an electric motor. This will be of the size used on 1000-kw. turbines and in operation so that all details of the movement can be observed by visitors. Reduction gear and turbine wheel details will be shown.

THE J. W. MURPHY CO., 431 S. Dearborn St., Chicago, Ill. Booth 324.

This exhibit will be divided into two parts, the first section containing a complete line of Rowan automatic motor starters, connected to a motor-driven fan so that any starter can be used for starting the equipment. Esterline meters will be mounted on a separate board and connected into the circuit to show the starting characteristics with these Rowan starters. A brake will be used or the fan throttled so that any desired starting load may be applied. In the second part of the exhibit will be found combustion instruments including a sectional model of the latest Hays automatic CO_2 and draft gage recorder to illustrate the principle of operation; also a working model of the Hays motor-driven CO_2 recorder. Connected to the fan blowers already mentioned will be a battery of the Hays slack leather diaphragm draft gages with illuminated dials, illustrating the sensitiveness of these instruments.

NATIONAL POWER CONSTRUCTION CO., Fisher Bldg., Chicago, Ill. Booth 452.

Photographs will be displayed of boiler settings installed by this company and details will be shown of representative jobs completed during the last two or three years.

NATIONAL TUBE CO., Pittsburgh, Pa. Booth 457.

Samples of Shelby seamless tubing, National boiler tubes, National pipe and other products of the company will be shown including the welding scale free pipe and Van Stone flanges.

NATIONAL VALVE & MFG. CO., 3101 Liberty Ave., Pittsburgh, Pa. Booth 127.

This company will show a varied line of fabricated piping equipment, featuring principally the new Navco Nos. 4-6-9 pipe joint recently developed for high steam pressures. The Navco universal pipe support will also be exhibited along with headers showing various methods of welding, reinforced welding and swedging.

NAYLOR-HICKEY CORP., 643 Washington Blvd., Chicago, Ill. Booth 42.

Bundy steam traps, Lonergan safety and water relief valves, steam and water gages and other specialties.

NICE BALL BEARING CO., 30th and Nicetown Lane, Philadelphia, Pa. Booth 425.

Industrial ball bearing and annular combination thrust and race types will be featured and in particular a pressed steel ball-bearing castor in sizes from 3 to 6 in. with dust cover and stationary cone.

NORMA-HOFFMAN BEARINGS CORP., Stamford, Conn. Booths 3-4.

This company will exhibit a complete line of Norma precision ball bearings, Hoffman precision roller bearings and thrust bearings of various types for power plant equipment. Several pieces of equipment will be shown with proper application of anti-friction bearings, also an instrument to show the amount of creep that takes place in the outer ring of a bearing when the inner ring is revolving or vice versa.

NORTHERN EQUIPMENT CO., Erie, Pa. Booths 86-9 and 124-7.

This company's exhibit will consist of a moving display of the Copes feed-water regulator showing the relation between boiler water level, steam and water flows and movement of the control valve of the regulator. Condensate drainage control, complete with tank and piping will also be shown and the B. I. A. control valve with method of adjusting the size of the valve ports while the boiler is in operation. Other features will be the Copes pump governor and water level indicator, based on balancing a constant head of water against the varying head of water caused by fluctuations in the level.

R. D. NUTTAL CO., Pittsburgh, Pa. Booth 104.

In this space, which will be used as a reception room for visitors, will be shown, tough hard gears and pinions of various types for use in railway, mining and industrial fields.

NUWAY BOILER & ENGINEERING CO., 53 W. Jackson Blvd., Chicago, Ill. Booth 188.

This company will exhibit a glass model of a Nuway supercirculation boiler showing direct, rapid, positive and guided circulation and demonstrating the efficiency, high-rate capacity and dry steam delivery of its method. Photographs of actual installations will also be shown covering a varied line of fuel burning devices, also photographs of the Nuway boiler with water walls and section of a header showing construction of these water walls.

THE S. OBERMAYER CO., 2563 W. 18th St., Chicago, Ill. Booths 467-8.

Refractory materials including high-temperature furnace cement and plastic monolithic material for furnace lining will be displayed and demonstration made of the method of applying the furnace lining material for making repairs. Illustrations will also be given of the results obtained from its use.

PAGE & LUDWICK, 14 E. Jackson Blvd., Chicago, Ill. Booths 443-4.

In this exhibit will be found the products of the Cleveland Worm & Gear Co., of the Thomas Flexible Coupling Co., of the Magnetic Mfg. Co., all in working models which will thoroughly illustrate the construction and method of operation of the devices.

PEABODY ENGINEERING CORP., 110 E. 42nd St., New York, N. Y. Booth 424.

Methods for burning oil, gas, and pulverized coal and viscosity regulators as produced by this company will be exhibited and the products shown in detail with drawings and blueprints of construction and installation.

PENNSYLVANIA CRUSHER CO., Liberty Trust Bldg., Philadelphia, Pa. Booth 198.

Bradford coal breaker and cleaner will be shown in the form of a working model, also the Armor-frame single roll crusher. Photographs will be in evidence of specialized machinery for crushing all kinds of materials.

THE PERMUTIT CO., 440 Fourth Ave., New York, N. Y. Booth 180.

For the company the principal and most interesting exhibit will be a model of water softening and filtering equipment as used in industrial plants. The model is about 4 ft. long, made exactly to scale after the design of a large commercial unit which delivers 100,000 gal. a day and shows small pipes and strainers in the interior of the water softening tank in miniature. This will illustrate the effectiveness of the zeolite process for the small plant as well as the large one. The Ranarex instruments for recording CO_2 will also be shown, operating on a purely mechanical principle and without delicate parts.

PITTSBURGH PIPING & EQUIPMENT CO., 43rd St. and A. V. R. R., Pittsburgh, Pa. Booths 98-115.

Special pipe fittings and construction will make up the display in this space. Included in this exhibit will be a welded pipe manifold showing a Sargol flange, a male and female flange, a Van Stone flange, a flange screwed and welded, a butt welded neck, an American neck and an example of swedging. Another welded pipe header will be deformed by having two necks pulled together to illustrate the strength of the weld. A cast-steel manifold will be exhibited, showing a Sargol flange, tongued and screwed flange, male flange, female flange and raised face flange. Samples of butt weld, inserted line weld and reinforced line weld will be shown, also of Van Stone joints in wrought steel and wrought iron.

PLIBRICO JOINTLESS FIRE BRICK CO., 1130 Clay St., Chicago, Ill. Booths 90-91.

The Plibrico booth will contain a moving picture outfit with films showing the installation of a complete monolithic lining under a 250-hp. oil-fired boiler at the plant of the Bosch Wall Paper Co. Also a wall of monolithic Plibrico will be built up and on exhibit, showing the new developments, with flexo-anchor which allows expansion and contraction in any direction, but anchors the refractory to the common brick so as to prevent bulging.

Wm. A. Pope, 26 N. Jefferson St., Chicago, Ill. Booth 85.

Heating specialties and high-pressure piping construction, also illustrations of piping systems which the company has erected.

The Wm. Powell Co., Cincinnati, O. Booth 449.

In this display will be arranged a representative line of valves of the company's manufacture, including bronze, iron and steel, globe, angle, cross, check and gate valves. Also will be shown oilers, grease cups, lubricators, water gages, oil gages, whistles, and injectors. These valves will be especially adapted for high pressures and temperatures but others for more moderate conditions will be in evidence.

Power Plant Specialty Co., 440 S. Dearborn St., Chicago, Ill. Booth 206.

Two proportioners one of the wet feed type and one of the dry feed type as used in the company's water softening installations will be exhibited, using as motive power for the proportioners or chemical feeders a duplex piston water motor. This motor, of constant displacement type, accurately measures the water going to the feeding apparatus and at the same time furnishes power for pumping or delivering the lime and soda ash to the feeding tank. Counter dials attached give a record of the water passing through. Photographs and mounted blue prints will illustrate the water softening installations which are made by the company.

Powers Regulator Co., 2120 Greenview Ave., Chicago, Ill. Booth 461.

Temperature control and methods of automatic operation of heating plants, water heaters and industrial equipment will be demonstrated in this exhibit. Included will be spring type and lever type of regulators, thermostats and auxiliary equipment for operating temperature control systems.

Power Specialty Co., 111 Broadway, New York, N. Y. Booth 162-5.

This exhibit will consist of a full-sized section of the Foster water-cooled furnace wall; a full-sized section of the Foster water back for use in stoker fired furnaces; sections of Foster superheaters showing a variety of constructions. Included also will be a typical construction of Foster header with extruded nozzle and a variety of smaller pieces of construction. A complete Aero pulverizer, with separator display of typical bearing having housing removed and stub shaft to show construction will be exhibited, also photographs, drawings and catalogs of the equipment manufactured by the company and of installations which it has made.

Henry Pratt Co., 2222 S. Halsted St., Chicago, Ill. Booths 38-9.

This exhibit will show the Phillips expansion joints for connection of steam turbines to condensers and the Phillips coal spout swinger for uniform distribution of coal to stoker hoppers, also the Pratt coal valve for control of the coal supply.

Quigley Furnace Specialties Co., 26 Cortlandt St., New York. Booths 192-3.

The company's entire line of boiler-room appliances, together with the triple-A solutions, protective coatings in black and colors, will be shown. The products include high-temperature cement for furnace walls, construction of baffles, use of the Quigley refractory gun, and the method of patching furnace linings by the use of Ganisand and Hytempite cement.

Racine Tool & Machine Co., Racine, Wis. Booth 186.

Racine shear cut production saw with 6 in. capacity and models of Racine high-speed metal cutting machines, motor driven, in operation.

Ramsey Chain Co., Inc., 1031 Broadway, Albany, N. Y. Booth 152.

Silent chain drives with roller bearings and compensating joint chains for taking up wear.

Reading Steel Casting Co., Bridgeport, Conn. Booths 132-33.

Cast-steel fittings and a new line of cast-steel valves conforming to the new A. E. S. C. standards will be exhibited, among them being included rustless steel-trimmed valves, a motor-operated valve and a hand-operated, ball-bearing-equipped valve. The fittings displayed will match the valves so far as the various classes are concerned.

Reeves Pulley Co., Columbus, Ind. Booth 211.

Here will be found a comprehensive exhibit of the Reeves variable speed transmission covering several different designs. A ball-bearing design will be shown, one with 4 to 1 speed ratio and remote electrical control, one with compact motor drive, having a constant speed motor of special make over the frame of the transmission and connected by a silent chain and sprocket. All recent improvements in construction will be demonstrated, including the new steel link V belt, force-feed system of lubrication, and self-alining mounting of ball thrust bearings.

Republic Flow Meters Co., 2240 Diversey Pkwy., Chicago, Ill. Booths 58-61.

Instruments will be featured as follows:

The new Republic boiler meter panel board, which gives complete survey of boiler efficiency on one-unit panel with continuous record of all essential data on one wide strip chart; the new Republic turbine meter panel board which gives a complete survey of turbine operation on one-unit panel with all records on one chart; the new Republic water-meter panel board, with indicating, recording and totalizing instruments for complete survey of pumping station operation; the Republic gas producer control panel, designed to indicate and record all data for efficient operation of an individual gas producer; the Republic gas producer control panel, a one-unit panel designed to indicate any irregularity in the operation of a battery of gas producers and to provide permanent record of battery efficiency. Individual Republic industrial instruments will also be included in the display.

Richardson Scale Co., Clifton, N. J. Booth 333.

Here will be found the model of a power plant with three boilers showing the use of coal weighing apparatus, one boiler being equipped with automatic coal scale for weighing coal from overhead bunkers to stoker, a second weighing coal from overhead storage to the pulverizer and a third with hand-weighing larry for weighing from the overhead bunker to the stoker hopper.

Riley Stoker Corp., Worcester, Mass. Booths 158 to 160.

Here will be exhibited a No. 3 Riley Atrita unit pulverizer, a two-retort Riley stoker with improved grate surface and a poppet valve for use with the steam-driven Jones stoker. The crusher will be shown motor-driven so as to illustrate the method of action, with cover removed so that details of construction can be studied.

Risher Fire Brick Co., 18th and Canal Sts., Chicago, Ill. Booth 42.

This exhibit will represent a complete line of fire brick, high-temperature cements and other refractories which the company carries at its Chicago warehouse. The intent is to show in a small way the most complete stock of refractories warehoused which represents a regular supply of 100 carloads.

Rollway Bearing Co., Inc., Syracuse, N. Y. Booth 466.

Heavy-duty roller bearings of the various radial and thrust types; also pillow block and line shaft bearings will be included in this exhibit.

Ross Heater & Mfg. Co., Buffalo, N. Y. Booth 437.

Several units will be displayed, among them a 4-in. riser expansion joint with design following standard construction of the company's internally-guided expansion joint; high-pressure, crosshead-guided expansion joint of new type with special slip tube, model of a vertical vapor condenser designed to reduce extreme corrosion to a minimum and with parts easily replacable. Another feature will be a three-stage Airjector unit for extreme vacuum such as is required for vacuum pan work, the units on exhibit producing vacuum of 29.8 in. as referred to a 30-in. barometer.

Rowan Controller Co., 431 S. Dearborn St., Chicago, Ill. Booth 324.

Automatic motor starters connected to a motor-driven fan so that any one of the starters can be used to start the fan equipment.

Sarco Co., Inc., 183 Madison Ave., New York, N. Y. Booth 10.

This company will show its thermostatic steam traps, temperature regulators and strainers and, as a special feature, the Sarco heating specialties for vacuum, vapor and pressure heating systems. These will include packless inlet valves and thermostatic radiator return traps.

Sauerman Bros., 438 S. Clinton St., Chicago, Ill. Booths 17-18.

In this exhibit the central feature will be a working model of the Sauerman power drag scraper system for storing and reclaiming coal, operating on a miniature power plant and supplemented by a moving-picture display showing typical scraper installations handling large tonnages of coal.

Schutte & Koerting Co., 12th and Thompson Sts., Philadelphia, Pa. Booths 170-1.

Power plant equipment and miscellaneous apparatus for industrial plants will be displayed, including in the first group a turbine generator, set up with trip throttle valve, multi-jet condenser, oil cooler and generator air cooler. The second group will show a double tube injector, spur and herringbone gear pumps, Radiafin tubes for heating and cooling air, piston valves, steam purifiers and other equipment. Photographs of equipment and of plants equipped with Schutte & Koerting apparatus will be found in the exhibit.

THE S-C REGULATOR MFG. CO., Fostoria, Ohio. Booth 35.

High-pressure and standard-type feed water regulators will be shown here, also pump governors and special regulating valves. Standard regulators for pressures up to 400 lb. and high-pressure regulators for 400 to 600 lb. will be demonstrated, also pump governors for pressures as high as 700 lb. Of special interest will be the S-C master control for handling reducing valves, pressures and boiler room equipment from a single station.

SCULLY STEEL & IRON CO., 208 S. LaSalle St., Chicago, Ill. Booth 40.

Construction and operation of the Everlasting blow-off valve will be demonstrated in this booth and the method of installation and proper operation shown.

THE SHARPLES SPECIALTY CO., 23rd and Westmoreland Sts., Philadelphia, Pa. Booth 109.

This company will exhibit a No. 6 Sharples portable super centrifuge for the purification of transformer oil, turbine and general lubricating oil; also a No. 5A stationary super centrifuge with electric motor drive for purifying various kinds of oils and

D. FROM COAL SUPPLY TO DISTRIBUTION OF ELECTRIC CURRENT, POWER PLANT EQUIPMENT WILL BE EPITOMIZED

a cross-section model of a super centrifuge showing the method of construction and operation. The No. 6 machine will be fully equipped with inlet and outlet pump heaters and all necessary piping valves and thermometers, mounted on a steel portable truck. It has a capacity on transformer oil of 400 to 600 gal. an hour.

D. H. SKEEN & CO., 53 W. Jackson Blvd., Chicago, Ill. Booths 52-5, 70-3.

In this space will be found the products of the manufacturers which the company represents in the Chicago territory. This will include Mercon regulators, Edward high-pressure steam valves, A-S-H, ash-handling systems, the Stets water level controller and Ljungstrom air preheater.

S.K.F. INDUSTRIES, INC., 165 Broadway, New York, N. Y. Booth 416.

All types of ball bearings, radial thrust, double roll, self-alining, and the application of ball bearings to hangers and pillow blocks wil be in evidence.

SKIDMORE CORP., 1535 Dayton St., Chicago, Ill. Booth 23½.

Here will be found an exhibit of vacuum pumps for condensing and heating systems.

M. B. SKINNER CO., 415 Washington Blvd., Chicago, Ill. Booth 191.

Unit pipe joint clamps, service saddles, pipe saddles, flanged clamps and reseating tools will form the exhibit here, a special feature being the high pressure saddle clamp for specially heavy construction and for use in confined spaces.

SNAP-ON WRENCH CO., Chicago, Ill. Booth 44.

Complete line of Snap-On wrenches will be exhibited in socket and open-end form, also engineers' and machinists' tools in single and kit form.

STANDARD OIL CO., IND., 910 S. Michigan Ave., Chicago, Ill. Booth 167½.

A display covering the entire line of petroleum products will be made, those relating specially to power plant lubrication being given particular prominence. Methods of manufacture and of testing lubricants and literature showing how to determine the proper kind of lubricants for different kinds of service will be available.

STANNARD POWER EQUIPMENT CO., 925 Monadnock Block, Chicago, Ill. Booths 46-51.

This company will exhibit steam and electric pumping equipment, including steam-driven wet and dry vacuum pumps, simplex and duplex boiler feed pumps, tank pumps, Magma and filter press pumps, hydraulic pumps, fuel oil pumps, air compressors, steam and electrically-driven condensate pumps, centrifugal bilge pumps, sand and gravel pumps and sump and chemical pumps, all as manufactured by the American Steam Pump Co. Sectional models of many of these pumps will be exhibited. Also on display will be the latest type of underground conduit for steam, hot water and oil pipes, as manufactured by the Ric-wil Co. of Cleveland, O., sections of actual conduit being shown. Nash Engineering Co.'s product will be exhibited, including the Jennings Hytor combined vacuum and low-pressure boiler feed pump, centrifugal pump, sewage ejectors, low-pressure condensers and condensation pumps. Many of these will be in actual operation, showing their effectiveness on present-day vacuum heating installations. Other features of the exhibit will be Reliance feed water heaters and steel tanks and Stickle bucket steam traps, oil separators and similar equipment as made by the Milwaukee Reliance Boiler Works and the Stickle Steam Specialties Co., of Indianapolis.

STERLING ENGINEERING CO., 1626 Holton St., Milwaukee, Wis. Booth 28.

In this company's exhibit will be shown a Model C Thermotrol, a self-contained automatic temperature regulator for use on two-pipe steam and hot water heating systems which regulates at the radiator without the use of wall thermostats, air compressors and air piping. Also the Sterlco thermostatic trap for use on vacuum

and vapor heating systems, operating by expansion of a vertical diaphragm. Another feature, the Sterlco graduated packless valve, with Jenkins Bros. disc equipment and made with either lever handle or mushroom handle.

STROM BALL BEARINGS Co., 4527 Palmer St., Chicago, Ill. Booth 13.

The display will include Strom radial single and double-row bearings, those with angular contact, also adapter-type and thrust bearings. Moving exhibits will illustrate the smooth operation of these bearings.

THE STRONG SCOTT MFG. Co., Minneapolis, Minn. Booth 133½.

Here will be exhibited model of the company's 3000 lb. per hr. Unipulvo coal pulverizing mill, complete in every detail, to quarter scale. There will also be shown a quarter-size model of a waste heat coal drier of sectional cast iron construction.

B. F. STURTEVANT Co., Hyde Park, Boston, Mass. Booths 411-13.

Here will be found a new type of induced-draft fan for straight-line installation in a vertical gas flow, a tubular air preheater and a propeller forced-draft type fan. The induced draft fan has a new type impeller blower with curved floats, radial at the tip and practically self-cleaning; the impeller is narrow and rugged and has a symmetrical housing with spiral inlets. Another feature will be the Sturtevant tubular air heater which will have lead-coated tubes and is arranged for the hot gases to pass vertically upward from the boiler, air entering the front side at the top and making a number of passes between and across the tubes. A flat plate type heater will also be shown working on counter-flow principle with the gas and air divided into alternate thin streams by steel sheets. Type Y economizer will be displayed with high-pressure lead-coated steel tubes, any tube being replaceable without disturbance of other tubes or of the headers. Another interesting feature will be a dust-collecting system, a unit ventilator, unit heater and a Sturtevant type 12 steam turbine.

THE SUPERHEATER Co., 17 E. 42nd St., New York, N. Y. Booths 96-7.

Two superheater units will be shown which have been in service for a number of years at the Hell Gate Station of the United Electric Light & Power Co. of New York and at the Fordson Plant of the Ford Motor Co. This exhibit will give opportunity to study the results of operation at high temperatures and under severe operating conditions. Literature will explain the construction and the conditions of operation under which these superheaters had to work.

THE SWARTWOUT Co., Cleveland, Ohio. Booth 462.

Ventilators and their application to actual boiler room ventilation will be demonstrated, also Swartwout separators, low-pressure float and high-pressure bucket steam traps and other Swartwout specialties.

THE TERRY STEAM TURBINE Co., Hartford, Conn. Booths 422-3.

In this exhibit will be found steam turbines, reduction gears and flexible shaft couplings, the turbines covering single and multi-stage machines. Details will show construction and operation, also the uses of reduction gears and couplings.

THOMAS FLEXIBLE COUPLING Co., Warren Nat'l Bank, Warren, Pa. Booth 443.

Adjustable shaft couplings for direct drive.

THE TIMKEN ROLLER BEARING Co., Canton, O. Booths 414-5.

Comprehensive display will be made of Timken bearings, also a novel and interesting machine shown to demonstrate positive alinement of the rollers in these bearings. This machine has four electro magnets, concealed beneath the table and connected with gear reduction unit and a small motor. As the magnets revolve, they attract the rollers which travel about the cone but are always positively alined, showing that the end cages serve simply to space, not to aline the rollers. The space will be arranged as a rest-room for visitors.

THE TRANE Co., La Crosse, Wis. Booths 326-7.

The main display here will be heat cabinets, a small portion of a wall being constructed to show how the concealed heat cabinets appear when placed inside the wall. This exhibit will be in operation to show how the cabinets work. Visible type heat cabinets will also be exhibited. This device is designed to be used in place of the usual steam or hot water radiator and for installation either in visible form or inside the walls of a building.

TROY ENGINE & MACHINE Co., Troy, Pa. Booth 169.

This exhibit will show in detail the construction and design of the Troy self-oiling steam engine, built to use high pressure and superheat on auxiliary drives. Also will be shown the Troy automatic self-oiling engine with capacities up to 200 b.hp.

UEHLING INSTRUMENT Co., Trenton, N. J. Booth 127.

Meter for showing fuel wasted up the chimney by recording percentage of CO_2 and temperature of escaping flue gases on one chart will be demonstrated in this display. The record shows when soot was blown, when scale was removed and indicates by-passing gases from leaky or broken-down baffles. Another feature will be a combined barometer and vacuum recorder.

THE UNISHEAR Co., INC., 79 S. Water St., Milwaukee, Wis. Booth 417.

Models A and O for cutting straight lines, curves and other complicated designs in sheet metal and model B with cutting capacities of plates up to ¼ in. thick.

UNITED STATES BUREAU OF MINES EXPERIMENT STATION, Pittsburgh, Pa. Booth 330.

Fuel utilization problems will be the subject of the display in this booth, one investigation now being carried on is that on boiler furnace refractories in co-operation with special research committee of the A.S.M.E. under the chairmanship of C. F. Hirshfeld. The exhibit will demonstrate methods by which measurements of furnace conditions are obtained and the flow of heat through furnace walls under operating conditions is measured. Another feature will be the investigation which is being carried on in co-operation with the New York Edison and other power companies as to the relationship of ash fusibility to clinker formation. Apparatus and methods of making determinations will be shown, also a number of exhibits illustrating characteristics of the clinker formation as related to the range of ash fusion temperatures.

VASTINE SALES CORP., 205 W. Harrison St., Chicago, Ill. Booth 151.

Operation of the Furnace Fire Observer which is inserted in the door or side wall of the furnace and permits the operator to observe conditions of the fire and brick work at all times will be demonstrated here.

HENRY VOGT MACHINE Co., Louisville, Ky. Booths 428-9.

This company will exhibit special valves and fittings for steam and hydraulic pressures up to 10,000 lb. per sq. in. on fittings and 6,000 lb. on valves. These are of drop-forged steel of special design and carefully tested for the service for which they are intended.

VULCAN SOOT CLEANER Co., Du Bois, Pa. Booth 438.

This company will exhibit the self-contained Vulcan valve-operating head, also the Vulcan ratchet head, late developments for the control of soot cleaner installations. Crodon and Super-Crodon blower elements will also be shown which, by using chrome alloy are given protection against sulphur gases and corrosion.

WALSH FIRE CLAY PRODUCTS Co., 360 N. Michigan, Chicago, Ill. Booth 332.

The company's brands of fire brick, including the xx brand, Walsh brand, Anchor brand and Anchor AA brand with high alumina content will be shown, also the standard hanging arch tile for arches under boilers where high heats and maximum efficiency are required. Other products will be boiler tube baffle and bridge wall tile, fire clay, glass house tank blocks, used for glass house melting furnaces, and a large retort head. The last two items are shown specially to prove the company's ability to make difficult shapes.

WALWORTH Co., Boston, Mass. Booths 56-7, 68-9.

Sigma steel gate valves will be shown for 400, 600 and 900-lb. working pressures, also a complete line of brass and iron body valves, sectioned for inspection of the construction. A machine will be demonstrated in actual operation for testing Kewanee unions with compressed air under water to show the perfection of the joint in these unions.

WARREN WEBSTER & Co., Camden, N. J. Booths 207-8.

The 1927 exhibit will show the latest development of the company's products in the fields of vacuum and modulation systems of steam heating to cover all stages of low-pressure steam usage. A new feature will be the handling of condensation and air through processed steam apparatus with many varied applications which make possible quicker handling through apparatus using steam at pressures up to 100 lb.

WESTINGHOUSE ELECTRIC & MANUFACTURING Co., Pittsburgh, Pa. Booths 102-3, 110-11.

Single retort underfeed stokers, designed to take advantage of the basic principles of design evolved from large central station stokers of multiple retort underfeed type will be the feature of the exhibit in this space. Details embodied are easily removed and replaced parts, uniform coal feed, insured by accurately governed engine, a grate motion which can be regulated independent of the main coal feed, safety mechanism to avoid damage by foreign substances. Other features to be found in the exhibit will be the new Westinghouse turbines, types AMD, also type EHNC.

WESTON ELECTRICAL INSTRUMENT CORP., Newark, N. J. Booth 309.

A complete line of portable instruments as well as a representative group of Weston switchboard instruments will be on display, showing the rectangular meters and the details of con-

struction and method of operation of all apparatus. A special feature will be the Weston electric speed indicator, demonstrating the application of generation of electrical potential to measurement speed.

WHEELER CONDENSER & ENGINEERING CO., Carteret, N. J. Booths 112-14.

As a chief feature will be shown a model of a surface condenser equipped with special valves for reversing water flow to the steam condenser. Smaller apparatus such as steam jet air pumps, hot well pumps, expansion joints and a model of one type of evaporator will also be exhibited with numerous photographs and slides of larger Wheeler equipment.

C. H. WHEELER MFG. CO., Lehigh and Sedgley Aves., Philadelphia, Pa. Booths 80-1.

This exhibit will consist of different types of Radojet air pumps, a sectional model of the pump showing construction and operation of the two-stage type being shown, also a three-stage for extremely high vacuums, 0.04 in. absolute on dead end tests. A latest-type, two-stage Radojet pump will be shown with surface inter and after condenser to be used in connection with closed feed water systems and with special features for cleaning condenser tubes. New type float control will be shown for inter and after condenser draining. Photographs of large condenser installations of dual bank type will be shown, one in particular being that of the 70,000-sq. ft. condenser for the Richmond station of the Philadelphia Electric Co.

THE WICKES BOILER CO., Saginaw, Mich. Booth 454.

A full-size corner section from the single-joint header of the company's horizontal cross-drum boiler will be displayed and a Baloptican lantern slide machine will show views of shop operations and actual installations. Literature describing the products of the company will be distributed and engineers will be present to answer questions on design and construction.

WILLIAMS PATENT CRUSHER & PULVERIZER CO., 2701 N. Broadway, St. Louis, Mo. Booth 441.

This company will exhibit a model of its improved ring crusher as well as an actual-size machine. Another feature will be a Little Giant type crusher sold for reclaiming old fire brick to be used for furnace patches, baffles, fire walls and the like.

WORTHINGTON PUMP & MACHINERY CORP., 115 Broadway, New York, N. Y. Booths 36-7.

Display will be made of the Diesel solid injection oil engine, type OS centrifugal pump, air compressors, vertical air compressors, steam power pumps and water and oil heaters.

WRIGHT-AUSTIN CO., 315 W. Woodbridge St., Detroit, Mich. Booth 439.

Three new products will be displayed which have been developed during 1926, the Wright-Austin bucket trap, the "quick change" water gage with glass replacing union, and the "clear view" gage glass protector. Of interest to visitors will be the contest for a name for the new bucket trap which will be in progress during the show. Other features shown will be the "crescent" weighted try-cocks, and the monel metal whistle valve. The gage glass protector is a semi-circular piece of wire glass surrounding the gage glass on three sides giving a clear view and having at the back a wire screen which prevents the gage glass flying out of the protector in case it should break.

YARNALL-WARING CO., Chestnut Hill, Philadelphia, Pa. Booths 209-10.

This company will exhibit a full line of Yarway blow-off valves for all pressures, including the recently developed valves with protected packing for pressures up to 900 lb. Also will be shown the Yarway-Lea V-Notch liquid meter in operation with hook gage for checking accuracy of the meter, as installed at the Richmond station of the Philadelphia Electric Co. Involute spray nozzles with improved design of combination Humptee, also nozzle specially developed for use in aeration of water will be demonstrated.

YEOMANS BROS. CO., 1433 Dayton St., Chicago, Ill. Booths 214-15.

This company will exhibit its screenless sewage ejector of centrifugal type employing a nonclogging impeller which passes solids without the use of screens; the Shone pneumatic sewage ejector operating by compressed air; a nonclogging sewage pump employing nonclogging impeller and designed principally for municipal service; a horizontal centrifugal pump for handling all kinds of liquids in house supply and general service.

THE INTERNATIONAL PAPER CO. has applied for a preliminary permit under which it is proposed to initiate power developments involving various creeks and lakes on Revillagigedo Island, near Ketchikan, in southeastern Alaska, within the Tongass National Forest, from which power will be used in manufacture of paper.

Apparatus Makers Define Terms

AFTER CONSIDERABLE WORK, the Association of Scientific Apparatus Makers of the United States of America, in conjunction with the Bureau of Standards and other authorities, have compiled standardized definitions of pyrometric terms. The following are a few of the definitions adopted:

Pyrometer: A device for measuring high temperatures. The term is applied to those devices, the principal use of which is for measuring temperatures above a red heat (about 500 deg. C.).

Resistance Thermometer: A thermometer which indicates temperature by means of the change with temperature of electrical resistance of one of its parts. It is a pyrometer when used at high temperatures (above 500 deg. C.), and, in such case, is preferably called resistance pyrometer.

Radiation Pyrometer: A pyrometer which indicates temperature by means of the change with temperature of the heat radiated by a hot body. As nearly as possible the total heat radiated is used. Usually this temperature is measured by a thermocouple.

Optical Pyrometer: A pyrometer which indicates temperature by means of the change with temperature of the light emitted by a hot body. As nearly as possible light of a single color (wave length) is ordinarily used.

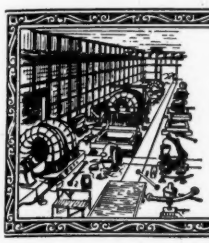
Thermoelectric Pyrometer: A pyrometer which indicates temperature by means of the change with temperature of the e.m.f. of a thermocouple. It ordinarily consists of a thermocouple, a millivoltmeter (or other means of measuring e.m.f.) and connecting leads. The measuring instruments may be classified as follows: Millivoltmeters, potentiometers and their combination or modifications.

Accuracy: In specifying the accuracy of a pyrometer the maximum error shall be expressed as a percentage of the full scale reading; or it may be specified as the maximum number of degrees of temperature.

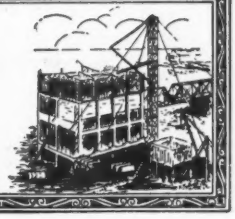
Sensitivity: The sensitivity of a pyrometer is its susceptibility to small changes of the temperature being measured. Specifically, it is defined as the smallest change in temperature which will cause a variation of one millimeter in the reading of the pyrometer.

Explosive Mixtures of Gas and Air

ANY COMBUSTIBLE gas or vapor, when mixed with air or oxygen within certain limiting proportions, will explode on ignition, warns the Bureau of Mines. The violence of the explosion varies with respective proportions of air and gas, and with the degree of confinement of the mixture. The explosive range of mixtures of common combustible gases and air varies from 3.1 to 10.7 with ethane to 2.5 to 73 for acetylene, hence mixtures of acetylene or hydrogen and air are much more likely to be within the explosive range than ethane, methane, or natural gas. Gasoline and acetylene are also extra hazardous in that only 1.5 and 3 per cent, respectively, are required in the mixture to reach the lower explosive limit.



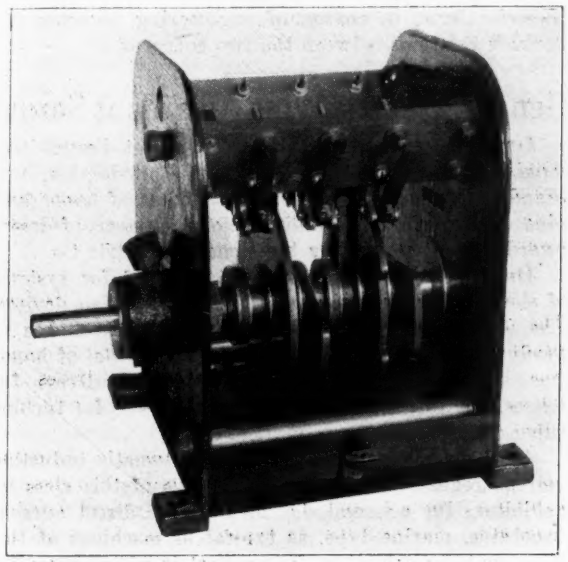
POWER PLANT ENGINEERING DEVELOPMENTS AND NEWS



New Cam-Type Limit Switch

IN THE ACCOMPANYING illustration is shown a view of a new cam-type limit switch, recently developed and placed on the market by the Electric Controller & Manufacturing Co. of Cleveland, Ohio. This switch is designed for use with magnetic controllers for the automatic control of machines having such fixed sequence of operation as slowing down, stopping and reversing.

In the photograph the switch is shown with the cover removed, but is normally totally enclosed. It is



NEW CAM-TYPE LIMIT SWITCH OF THE ELECTRIC CONTROLLER & MFG. CO.

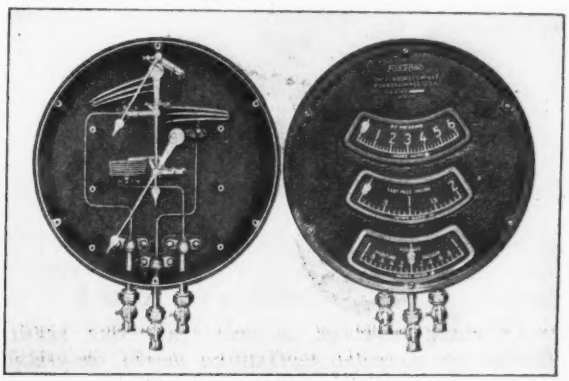
equipped with tapered roller bearings and is designed to carry up to six sets of contacts. The cams which operate the opening and closing of the contacts are each adjusted independently of the others and can be fixed at any number of positions, thus giving extreme flexibility to the machine with which it is used.

Compact Multiple Draft Gage

INCREASED DEMANDS for draft gages in modern power plants led to the development of a series of single, duplex and triplex gages by The Foxboro Co., Inc., Foxboro, Mass.

Actuating movements of these gages consist of a series of metal diaphragms built up in the form of a bellows, as shown in the left-hand side of the illustration. Pressure tends to elongate and vacuum to contract the tube and the resultant motion of one side is multiplied by restraining the motion of the other side with a small helical coil spring. These springs create the required amount of motion with the reduced number of diaphragms and the lateral motion is translated into a rotary motion and transmitted to a shaft by means of simple levers.

Duplex and triplex instruments are furnished in a 12-in. round cast-iron case with screw holes for mount-



INTERIOR AND EXTERIOR VIEWS OF THE TRIPLEX GAGE

ing. A cover with a heavy felt gasket is designed to make a dust and moisture-proof case. Connections are made by means of standard ground joint union stop and waste cocks which permit closing off the instrument while blowing tubes, as well as permitting a zero check of the instrument by opening up to the atmosphere. Large dart pointers with slender tips stand out conspicuously against the black background and dials with special ranges or identification plate with special markings can be furnished if desired.

Automatic Alternator for Duplex Pumps

ESPECIALLY DESIGNED to alternate automatically the operation of each pump in a duplex unit, an automatic alternator has recently been added to the Chicago vertical pumps made by Chicago Pump Co., Chicago, Ill. It is stated that this new device is the only one of its kind on the market today. It is designed to eliminate the old transfer switch or button method. It operates so that the work is shifted automatically from one pump to the other, operating No. 1 pump, then No. 2, then back to No. 1 and so on.

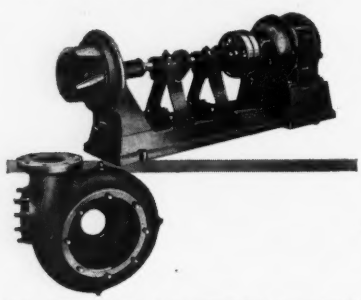
In addition to automatically alternating the operation of duplex equipment, this alternator is designed to start the pump that is not in operation, in case the

pump in operation fails or is unable to handle all the water. Thus, during an emergency or flood condition, both pumps will be automatically cut in and will continue to operate until normal conditions are restored, at which time they will resume their alternate operation as before.

Non-Clogging Centrifugal Pump

THE American Well Works of Aurora, Illinois, has just placed their non-clogging centrifugal pump on the market. The design of this pump marks a new departure in construction and obviates the necessity of screens and their expensive maintenance.

Stream lines are not separated in the operation of this pump due to the peculiar design of the single blade propeller, the stream of fluid being kept in one mass during its entire passage through the pump. By compelling all the liquid and debris to be discharged through a single peripheral passage, the possibility of



SINGLE BLADE IMPELLER OF PECULIAR DESIGN PERMITS PUMPING OF MATERIAL CONTAINING GRITTY OR STRINGY SUBSTANCES WITHOUT CLOGGING

different portions of a single piece of debris being swept into different outlet passages and thereby being hung up within the impeller, is avoided, thus the necessity of screening sewage or fluid containing other solid matter, before pumping is not required.

Fluids containing stringy matter, mineral matter, animal matter, vegetable matter, such as hair, strings, waste, shavings, rags, mud, chips, sand, sludge, wire, debris, slaughter house and fish market refuse, offal, fat, grease, weeds, straw, stable flushings, etc., can be handled successfully.

This pump is made in both vertical and horizontal types and is adapted for municipal sewage and general industrial use. Engineering information may be obtained from the engineering department of this company.

New Directors Bring Important Interests Into American Brown Boveri

STOCKHOLDERS OF the American Brown Boveri Electric Corp., at their annual meeting Wednesday, January 5, at the corporation's executive offices, 165 Broadway, New York, unanimously approved the election of directors by the voting trustees on Tuesday. The new board of directors consists of 14 members: namely, Clifford Bucknam, Pynchon & Co.; James I. Bush, vice-president of the Equitable Trust Co.; Allen Curtis, of Curtis & Sanger, Boston; William M. Flook, representing the Anthony N. Brady estate; Edward N. Goodwin, representing Brown, Boveri & Co., Ltd., of Switzerland; William V. Griffin, representing the Anthony N. Brady estate; James Imbrie, president of Imbrie & Co.; William F. Ingold, of Pynchon & Co.; Henry Lockhart, Jr., vice- president of Blair & Co., Inc.; John J. Rudolf, of A. Iselin & Co.; Theodore G. Smith, vice-president of the Central Union Trust Co.; Elisha Walker, chairman of the board and president of Blair & Co., Inc.; Frank R. Warton, formerly vice-president of the Allied Packers Co., and Laurence R. Wilder, president of the American Brown Boveri Electric Corp.

The following officers of the corporation were elected on Wednesday: Laurence R. Wilder, president; Clinton L. Bardo, Theodore Boveri, W. G. Groesbeck, Earle G. Hines and Frank R. Warton, vice-presidents; Norman R. Parker, comptroller, and J. T. Wickersham, secretary and treasurer.

Theodore Boveri, son of the late Walter Boveri, one of the founders of Brown, Boveri & Co., Ltd., was for many years responsible for design and manufacture in the Baden, Switzerland, works of Brown Boveri. His election as vice-president of the American Brown Boveri Electric Corp., in charge of engineering, cements the working relations between the two concerns.

General Electric Wins Awards at Sesqui

OF THE PRIZES awarded at the recent Sesqui-Centennial International Exposition at Philadelphia, two grand prizes, together with three medals of honor and nine gold medals, in addition to a number of lesser awards, were received by the General Electric Co.

One of the grand prizes was awarded for systems of electric transportation and traffic regulation devices. The other grand prize was awarded for excellence of products and service to humanity. One medal of honor was awarded for gas-electric system of drives for busses, one for G. E. Mazda lamps, and one for turbine super-charger.

Gold medals were awarded for automatic induction voltage regulator typical of apparatus of this class by exhibitor; for a.c. and d.c. motors; for direct current generator, marine type, as typical of machines of this class made by exhibitor; for an electric mine locomotive fitted with automatic cable reel of high efficiency; for emergency automatic throw-over switch mounted on vertical steel panel; for motor-generator set typical of machines made by exhibitor and for type H transformers.

Westinghouse Awarded Nine Prizes at Sesquicentennial

AT THE SESQUICENTENNIAL International exposition at Philadelphia the executive jury of awards has voted to the Westinghouse Electric & Manufacturing Co. nine awards for its exhibits, including a Grand Prize for "excellence of products and service to humanity."

The awards, other than the Grand Prize include, one medal of honor, four gold medals, and three silver medals, distributed as follows: Medal of Honor—for outstanding development work resulting in the "OB" watthour meter; Gold Medal—for the Osiso-Oscillograph, a device for recording the characteristics of electric cur-

rents; Gold Medal—for farm light and power plant; Gold Medal—for the development of the bi-metallic thermostatic control switch; Gold Medal—for the excellent construction and quiet operation of electric fans; Silver Medal—for improvements made in lighting fixtures; Silver Medal—for the development of household heating appliances; Silver Medal—for household electric cell.

Charles E. Squires

MR. SQUIRES, for many years a familiar figure at gatherings of power plant men, President and Treasurer of the C. E. Squires Co., passed away on Dec. 9, 1926, leaving his wife and three daughters.

Born on Sept. 5, 1864, in Bayport, Mich., Mr. Squires went to Cleveland, O., when 18 yr. of age to work as a steam fitter. Of active mind and seeing the needs of the field, he invented the Squires boiler feed water controller, three types of pump governors, a reducing valve and the three types of steam traps which bear his name. To care for the growing business in these specialties, he formed in 1904 the C. E. Squires Co. of which he was president and treasurer up to the time of his death.

By his extensive traveling and good fellowship at conventions and gatherings of engineers, Mr. Squires made hosts of friends throughout the country, who will feel that a valued and helpful colleague is lost to them. He achieved double success as a creator of equipment to meet power plant needs and as a business man in supplying the market. His life has been a benefit to the men and the industry with which he has been associated.

News Notes

AS THE RESULT of a year's work on the part of the Steering Committee of the Oil Power National Conference, Oil Power Week, scheduled for April 18 to 23, 1927, promises to assume more importance than in previous years. Fifty meetings have already been announced and this number will probably be increased. Among the subjects to be discussed at these meetings will be: injection nozzles and fuel pumps for high speed oil engines; research work on oil engine combustion; engine fuel from coal distillation; oil engine development for aircraft; operating experiences with various fuels; and the oil engine as a decentralizer of industry.

THE MIDWEST NATIONAL meeting of the American Society of Mechanical Engineers will be held at Kansas City, Mo., on April 4, 5 and 6. The Kansas City section, under the leadership of F. S. Dewey, is planning an extensive program of technical papers, excursions and entertainment.

PUBLISHED PROCEEDINGS of the International Conference on Bituminous Coal, held under the auspices of the Carnegie Institute of Technology, from Nov. 15 to 18, 1926, will be available some time during February or March, according to an announcement from that institution. Orders for copies should be sent to Arthur C. Jewett, director of the College of Industries, Carnegie Institute of Technology, Pittsburgh, Pa.

AN UNUSUAL AND INTERESTING stoker installation is to be made on a ship now being built for service on the Great Lakes by Bradley Transportation Co. at Lorain, O. The boilers on this ship will be set higher than is usual in marine practice and will be fired with Westinghouse multiple retort stokers equipped with clinker grinders. Air preheaters will be used with these boilers, which will supply steam to the turbo-generator for driving the ship through motors. The ship is to be used for transporting limestone on the Great Lakes.

M. B. URQUHART, for the past 20 yr. Northwestern manager for the Keystone Lubricating Co. of Philadelphia, Pa., has resigned that position and assumed the Western management of the Philadelphia Grease Mfg. Co. with offices in the Ideal Building, Denver, Colo., and 144 South 5th West Street, Salt Lake City, Utah.

Mr. Urquhart's wide acquaintance in the territory which he has covered so many years and his engineering knowledge and ability are a guarantee of "Mike's" success in his new position.

MCCLAVE-BROOKS, Scranton, Pa., announces that after Feb. 1, 1927, its Chicago office will take over the territory handled by the St. Louis office, which has been discontinued. The Chicago office will also serve Kansas and Nebraska.

YEOMANS BROTHERS CO., Chicago, Ill., announces that Purdy & Henderson Trading Co., Havana 55, esquina a Empedrado, Havana, Cuba, has been appointed sales representative for that territory, handling a complete Yeomans line of pumping equipment.

ELLIOTT CO., Jeannette, Pa., which has recently acquired the Ridgway Dynamo & Engine Co., announces the consolidation of the district sales and service offices of the two companies, the Ridgway men joining forces with the Elliott personnel. In some cases the former Elliott offices have been retained in the old location, while in others new and larger quarters have been found necessary.

ANNOUNCEMENT is made by The Jeffrey Mfg. Co., Columbus, Ohio, that the year 1927 marks the 50th anniversary of the founding of this company, which occurred in 1877. At that time the company began the manufacture of a machine for cutting coal mechanically, in which certain new types of chain were used for power transmission. A member of a local manufacturing company, then known as the Columbus Rolling Mills, while visiting the Jeffrey workshop, noticed several pieces of this chain on the floor and inquired if it might not be used as a drive for the feed rolls in their mill. It was found that it could be applied to this work and from this beginning the chain department of the Jeffrey com-

pany developed. The development of chain drives for use on stern wheel steamers on the Mississippi River soon followed and it was not long before chains were applied to several types of material conveyors which had been using rope. Other types of chains and conveyors were the natural development from this, resulting in the present complete line of Jeffrey coal mining equipment, Jeffrey tipples, elevators, conveyors and crushers.

THE OIL & GAS POWER NATIONAL CONFERENCE has designated a national prize for the best paper under its program as the Rudolf Diesel prize award. This consists of $100 in cash and an engrossed certificate. The paper is judged on its merits and on the degree to which it conforms to the spirit and aims of the Conference. The 1926 prize was formally presented to Fred Thilenius, master mechanic of the Prairie Pipe Line, on December 9, 1926, by D. H. Killeffer, editor of Industrial and Engineering Chemistry, at the Oil and Gas Power Session of the A.S.M.E. annual meeting.

ARTHUR L. RICE, editor of Power Plant Engineering, and a graduate of Worcester Polytechnic Institute in the class of '91, represented the Institute at the 13th annual meeting of the Association of American Colleges, held January 13 to 15, 1927 at the Congress Hotel, Chicago, Illinois.

Mr. Rice received a degree of B.S. in mechanical engineering from Worcester in 1891 and a degree of B.S. in electrical engineering in 1893. From 1892 to 1895 he was in charge of the steam engineering laboratory at the Institute and in 1896 received his degree of M.M.E. from Cornell.

DR. M. L. HARTMANN has resigned as director of research of the Carborundum Co., Niagara Falls, N. Y., to become technical director of the Celite Products Co., whose research laboratory is located at Lompoc, Calif.

Dr. Hartmann is a graduate of the University of Arizona and received his doctor's degree from Harvard University. He was formerly head of the department of chemistry, South Dakota State School of Mines and has for the past 9 yr. been in charge of the research department of the Carborundum Co.

STEPHENS-ADAMSON MFG. CO. has opened a new branch sales office at 472 Hanna Bldg., Cleveland, O., which will be in charge of John G. Stewart and J. L. Langner, both well known in that territory. Mr. Stewart has been actively associated in the conveying business for many years and has gained an enviable reputation as an engineer of ability and a designer of material-handling, labor-saving equipment. Mr. Langner, who will be associated with Mr. Stewart in the Cleveland office, is familiar with this class of engineering.

HENRY N. WINNER, general manager of The Garlock Packing Co., Palmyra, N. Y., died at Philadelphia on November 12, 1926, after a very brief illness. Mr. Winner was born in Brooklyn, September 19, 1879, and spent his entire life in the mechanical packing business. For many years he worked as a salesman out of the New York City office of The Garlock Packing Co. and later was sales manager of the Philadelphia district office. He was general manager of the company for the last four years with headquarters at the general office, Palmyra, N. Y.

At different times he has also served other packing manufacturing companies, being sales manager of the mechanical packing division of Johns-Manville, Inc., and manager of the packing department of the United States Rubber Co.

L. J. WING MFG. CO., New York City, has appointed the Sheffler-Gross Co., Inc., 205-11 Drexel Bldg., Philadelphia, Pa., as representative for its product.

ANNOUNCEMENT IS MADE that Steere Engineering Co. has been combined with a new company, the Semet-Solvay Engineering Corp., a division of the Allied Chemical & Dye Corp. of New York City.

THE AUBURN STOKER CORP., Auburn, Ind., manufacturers of hand-operated, semi-mechanical and full mechanical Auburn stokers, announces the opening of its general sales office at 8 So. Dearborn St., Chicago, Ill., in charge of F. A. Moreland.

OTTOMAR H. HENSCHEL has established offices for the practice of consulting engineering at 50 Keefe Avenue, Milwaukee, Wis., specializing in the design, construction and operation of steam and electric power generating, distribution and utilization systems for industrial plants and commercial buildings.

ANNOUNCEMENT IS MADE that R. H. Beaumont Co., Philadelphia, Pa., has adopted Tru-Lay brand performed wire rope, manufactured by American Cable Co., New York, as standard equipment on its various types of coal-handling equipment, such as skip hoists and drag line scrapers.

ELLIOTT CO., Jeannette, Pa., announces that R. H. Carter has joined its Detroit district office. Mr. Carter was with the New York Shipbuilding Co. during the war and was chief engineer in the South American service for the Munson Steamship Lines afterwards. Recently he constructed and put in operation the new turbine installation of the Illinois Steel Co. at Gary, Ind.

THE SAVANNAH ELEC. & POWER CO., Savannah, Ga., has recently put into operation a new 15,000-kw. turbo-generator, installed under the direction of Stone & Webster, Inc., designers and engineers. This installation, together with that of two 400-hp. pulverized coal-burning boilers, is expected to effect material savings in operating costs of the Savannah Co., which is a subsidiary of Engineers Public Service Co.

MCCLAVE-BROOKS CO., Scranton, Pa., announces that Alfred Lotz, formerly of the Underfeed Stoker Co. of America, assumed his duties on January 17 as manager of the Chicago territory. H. P. Grohn will act as assistant manager. The company also announces the removal of its Cleveland district office to Pittsburgh, Pa., with headquarters at 304 Oliver Bldg. H. E. Passmore is manager.

ACCORDING to a recent announcement of the Westinghouse Electric & Mfg. Co., the corporate form of two of its subsidiaries has been discontinued and merged into the parent company as branch works. The companies so affected were the Westinghouse Electric Products Co., of Mansfield, Ohio, and the George Cutter Co., of South Bend, Ind. In the future they will be designated as the Mansfield Works and the Street Lighting Department, respectively, of the Westinghouse Electric & Manufacturing Co., the latter including the South

Bend Works, which is one of the largest in the country devoted to the manufacture of street lighting equipment with branches for the manufacture of poles of the "hollowspun" type located in Milwaukee, St. Louis and Valdosta, Ga.

The Mansfield Works is devoted to the manufacture of domestic electric appliances, including electric ranges and ovens and safety switches.

THE MISSISSIPPI POWER CO., Gulfport, Miss., is considering preliminary plans for a new hydro-electric plant on the Tennessee River, near its junction with Bear Creek. The project will include a large power dam about 5000 ft. long and 50 ft. high. The initial power installation will be for 70,000 hp., designed for an ultimate of 200,000 hp. An application covering this project has been filed with the Federal Power Commission.

CALIFORNIA-OREGON POWER CO., a subsidiary of Standard Gas & Electric Co., has begun work on a new hydro-electric development on the north fork of the Rogue River in Oregon, according to an announcement of H. M. Byllesby & Co. The new plant will have an initial capacity of 22,000 hp. and an ultimate capacity of 66,000 hp. Prospect No. 2, as the plant will be called, will be built on the Rogue River above the existing No. 1 development, which has a capacity of about 6300 hp. The plant will operate under a head of approximately 600 ft. and it is planned to operate it on a 97 per cent annual load factor. It will be tied in with the company's system at Medford, Ore.

PRELIMINARY PERMIT granted by the Commission to the Connecticut River Co. for a power development on the Connecticut River in Hartford County, Conn., and Hampden County, Mass., having expired in November, 1924, the Northern Connecticut Power Co., of which the Connecticut River Co. is one of the merged companies, has filed application for a license to develop the same project. The company's plans call for the construction of a concrete dam in two parts—the east channel spillway dam to 1150 ft. in length and to rise 17 ft. above the river bed, and the west channel spillway dam to be 500 ft. long and to be 23 ft. in height above the river bed. The project will include a canal, forebay, and a power house which will ultimately contain six units capable of developing 8300 hp. each.

PLANS HAVE BEEN consummated for the proposed merger of the Newport News & Hampton Ry., Gas & Elec. Co., Newport News, Va., with the Virginia Public Service Co., Alexandria, Va., the latter operated by A. E. Fitkin & Co., New York.

THE CENTRAL WEST PUBLIC SERVICE CO., Columbus, Nebr., recently formed under Delaware laws, plans to take over the Platte Valley Power & Light Co. and its subsidiaries, as well as a number of independent power interests to serve territories around Columbus and Norfolk, Nebr., Rapid City and Hot Springs, S. D., and Jamestown, N. D. W. N. Albertson is president.

GEORGE T. CAMERON has applied to the Federal Power Commission, Washington, D. C., for a preliminary permit for a power project near the mouth of the Speel River, at Snettisham Inlet, in southeastern Alaska, proposing to use the developed power in operating a paper mill designed to produce 200 to 600 t. of newsprint paper a day. It is planned to erect a power plant near the mouth of the river but the location of the proposed paper mill has not been determined.

A NEW COMPANY, to be financed by Taylor, Ewart & Co. of New York, and to be identified with A. H. Bickmore Co., 111 Broadway, New York, is perfecting plans for a merger of ice manufacturing plants in Connecticut. Options have been secured on plants in Hartford, Waterbury and New Britain and negotiations are under way for properties in Meriden, New London and Stamford.

THE CONNECTICUT LIGHT & POWER CO., Waterbury, Conn., has plans under way for the construction of a new power plant on the site of its present station at Leesville.

THE JAPANESE ELECTRIC BOND & SHARE CO., Tokyo, Japan, has been formed with a capital of 10,000,000 yen to take over and develop existing light and power interests in that country. The new company is patterned after the Electric Bond & Share Co. of New York and two officials of this company, A. W. Burchard and S. Z. Mitchell, will be on the directorate of the Japanese organization.

Books and Catalogs

ELEMENTARY MECHANISM by A. T. Woods and A. W. Stahl; revised and rewritten by Philip K. Slaymaker; cloth, 6 in. by 9 in.; 250 pages, 248 illustrations; $3.00, New York.

In revising Woods & Stahl's Elementary Mechanism, Prof. Slaymaker, of the University of Nebraska, has not only rewritten much of the original text but has also added considerable material. An entirely new chapter has been inserted on the subject of instant centers, discussing modern applications as used in the automobile, the bicycle, the trackless train and other equipment. In rewriting the chapters on gears the involute system has been given first place rather than the cycloid system. An effort has been made in revising to introduce modern applications and to bring the book up to date without making it too large for classroom use.

In the first edition Professors Stahl and Woods aimed to present much of the existing material on the subject of mechanism in a new form which would be suitable for mechanical engineering students and they selected their material from many sources. The idea, it seems to us, is a good one, provided such a book is periodically rewritten, as in this case, in order to show the latest applications of the principles discussed. It should be of interest to the designing engineer and contains much material that is valuable for reference by the power plant man who has anything to do with machinery that involves anything more than simple rotating parts.

BULLETIN 211-1, just issued by Power Specialty Co., New York, is a table of properties of steam up to 1200 lb. absolute pressure and 300 deg. F. superheat. The table is double bound, the sheets being stitched together so they can be removed and placed in the front of a standard Marks and Davis steam table. The table has been compiled to facilitate the work of those engaged in high-pressure, high-temperature steam engineering

and is not copyrighted. The data have been compiled as a result of the recent steam research program of the A.S.M.E., the General Electric Co., Harvard University and the other agencies now at work on the steam tables. This work, of course, has not been finished and new figures on total heat of the liquid will be delayed for some time. For convenient use in the meantime, this table is printed as a combination of the most reliable data available but cannot be considered as final or perfect. It should prove of great value to the whole power plant industry, as it is the first presentation in standard steam table form of the most recent information on steam properties at high pressures and temperatures.

THE NATIONAL DISTRICT HEATING ASSOCIATION has just issued the proceedings of its 17th annual convention held at Niagara Falls, June 1 to 4, 1926. At this convention interesting reports were presented by the Heating Research committee of the association, dealing with the question of combined electric power and heating steam generation; reports by the committee on operating statistics giving data on the boiler horsepower, amount of steam sold, coal burned, cost of fuel and many other interesting data concerning member companies; and reports by the station operating committee, heat utilization committee and others. The book also contains papers on furnace wall construction, powdered coal burning equipment and various district heating installations by prominent engineers.

IN ITS RECENTLY enlarged catalog No. 905-C, C. J. Tagliabue Mfg. Co., Brooklyn, N. Y., presents 104 pages of discussion of its Tag recorders with 320 illustrations. The bulletin begins with interesting discussions of the value of temperature records not only in the power plant but in industrial processes and then describes in detail the company's line of temperature recorders, giving complete details of construction. Dial indicating thermometers, mercury, vapor-tension and gas filled recording thermometers and pressure and vacuum recorders are described as well as Tag recording controllers. Complete lists are given of dimensions of the various pieces of equipment, together with their prices.

MCCLAVE-BROOKS CO., Scranton, Pa., has issued bulletins describing its chain grate stoker, one type of which is built for burning anthracite and coke breeze, the other type for bituminous and lignite. The grate is composed of a chain of links with approximately one-third of the grate under fire at one time and, as the links permit a flat surface, there is no chance for them to extend into the fire. The grate links are removable and can be changed while the stoker is in operation, if necessary. These stokers are made for both natural and forced draft work.

IN A RECENT BULLETIN, Everlasting Valve Co., Jersey City, N. J., describes in detail the blower drawoff Wylie Wilson process. In this process a closed drawoff tank suitable for full boiler pressure is interposed between the boiler blowoff valve and the discharge valve to the sewer. The blowoff water withdrawn from the boiler passes into the drawoff tank and when a predetermined amount of water has been drawn off at a predetermined velocity of flow the discharge from the boiler automatically ceases. The water is then withdrawn from the tank, preferably not at boiler pressure but at greatly reduced pressure. This process is designed to promote safety, efficiency and durability of all the apparatus involved, including the boiler, and to preclude the possibility of shock. It is extremely flexible, as is the apparatus, and can be made to suit almost any condition which may exist in boiler plants.

KINGSFORD MULTI-STAGE horizontal split casing centrifugal pumps are described and illustrated in bulletin No. 56 issued by Kingsford Foundry & Machine Works, Oswego, N. Y. These have impellers of the single-suction, enclosed type and the water passages are of the multi-volute type. Full details of bearings, lubrication system and wearing rings are given in the bulletin.

W. S. ROCKWELL CO., New York City, in leaflet No. 276, describes the Rockwell revolving retort type electric furnaces.

HOYT METAL CO., St. Louis, Mo., has sent out a 20-page booklet discussing the selection of babbit metal, designing of babbit bearings, preparation for casting the babbit and details of the Hoyt products.

WILLIAM M. BAILEY CO., Pittsburgh, Pa., has issued a circular describing the McGee goggle valve especially adapted to blast furnace gas mains and various types of power plant equipment.

IN ITS BULLETIN No. 36, the Aero Pulverizer Co., a subsidiary of the Power Specialty Co., New York, describes and illustrates the latest type of Aero pulverizer showing photographs of many interesting installations.

IN THE THIRD EDITION of its catalog, Weston Electrical Instrument Corp., Chicago, Ill., describes in detail all types of Weston electrical instruments for switchboard and portable use. Illustrations and complete details, together with price lists, are given of each type.

QUIGLEY FURNACE SPECIALTIES CO., New York City, has issued a booklet entitled "Protect Your Plant and Equipment" in which it deals with corrosion, its causes and methods of prevention and points out the distinctive features and characteristics of triple A solutions for use in power plants and allied industries.

BULLETIN No. 31, just issued by Smoot Engineering Corp., New York, contains an interesting discussion by H. K. Blanning of the machine regulation of pulverized coal fired boilers. Detailed discussion is given of the operation of pulverized coal fired boiler plants with data on typical plants and many illustrations, together with details of Smoot control and its application in many leading power plants.

THE MARLEY STEAM SUPERHEATER for horizontal return tubular boilers is thoroughly described and illustrated in a recent bulletin issued by the Power Plant Equipment Co., Kansas City, Mo. These superheaters are made in various types, depending on the steam connections desired, for all styles of fire tube boilers. The catalog also mentions the Marley non-clog spray nozzle.

THE WELLMAN-SEAVER-MORGAN CO., Cleveland, Ohio, is distributing a wall calendar for 1927. This calendar illustrates various installations of heavy loading and unloading machinery, gas producers and gas apparatus, steel works machinery, etc.

THE CLIMAX ENGINEERING CO., Clinton, Ia., has issued its 1927 wall calendar illustrating the company's gasoline engines, pumps and power units.